EIGHTEENTH ANNUAL REPORT

OF THE

Quebec Society for the Protection of Plants

1925-1926

Supplement of the report of the Minister of Agriculture

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QUEBEC
1926

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To the Honourable J. E. Caron, M.P.P.,

Minister of Agriculture,

Quebec.

Sir:—

I have the honour to present herewith the eighteenth Annual Report of the Quebec Society for the Protection of Plants, containing the proceedings of the winter meeting of the Society, which was held at Macdonald College, Ste. Anne de Bellevue, Que., on Thursday, April 15th, 1926.

Included are the papers that were read, and the reports of the officers of the Society.

I have the honour to be,

Sir,

Your obedient servant,

E. Melville DuPorte,

Secretary-Treasurer.

Macdonald College, Quebec.

QUEBEC SOCIETY FOR THE PROTECTION OF PLANTS

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Delegates to the Canadian Branch of the American Phytopathological Society, Dr. B. T. Dickson, Rev. Father Leopold, Mr. O. Caron and Mr. J. J. Coulson.

Delegate to International Plant Congress:—Dr. B. T. Dickson.

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Vanterpool, T. C.	Macdonald College.
Victorin, Rev. Bro.	University of Montreal, Montreal.
White, R. M.	Entom. Lab. Treesbank, Man.
Willey, Dr. A.	58 Metcalfe St., Montreal.
Winn, A. F.	32 Springfield Ave., Westmount.

HONORARY MEMBERS

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F. C. Harrison, D. Sc., Macdonald College.
Rev. Father Superior Dom Pacome Gaboury, La Trappe, Que.
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Canon, V. A. Huard, D. Sc., Quebec.
Rev. Father Superior, Ste. Anne de la Pocatière.
J. C. Chapais, D. Sc., St. Denis en bas, Que.
A. Gibson, Esq., Dominion Entomologist, Ottawa.
Hon. Minister of Crown Lands and Forests, Quebec.
Prof. W. Lockhead.....Macdonald College

FINANCIAL STATEMENT

QUEBEC SOCIETY FOR THE PROTECTION OF PLANTS. EIGHTEENTH ANNUAL MEETING.

Receipts

Balance forward	$ 178.39	
Government Grant	250.00	
Interest	8.02	
		$436.41

Expenditure

Delegate to Royal Society	$ 15.95	
Printing, postage and clerical	24.71	
Secretary	50.00	
Delegates to Phytopathological Society	74.95	
Delegate to Entomological Society	9.60	
Speaker at Annual Meeting	41.31	
General expenses of Annual Meeting	16.50	
Balance in hand on May 14, 1926	203.39	
		$436.41

Examined and found correct

J. C. COULSON,
Auditor.

W. LOCHHEAD,
President.

E. MELVILLE DUPORTE,
Secretary treasurer.

ANNUAL MEETING

The eighteenth annual meeting of the Quebec Society for the Protection of Plants was held in the Biology Building, Macdonald College on Wednesday, April 15th, 1926.

There was a satisfactory attendance chiefly of members of the Federal and the Provincial departments of Agriculture, members of the staff of Macdonald College, graduate and other students, and others connected with agriculture, forestry and the agricultural press.

The special speaker for the evening session was Dr. Donald Folsom, Plant Pathologist of the Maine Agricultural Experiment Station. Dr. Folsom's work on virus diseases of potatoes is well-known and his excellent address on the subject was heartily appreciated.

Principal F. C. Harrison gave a short address of welcome to members and guests. He regretted the absence of the Rev. Father Leopold and of Dr. Chapais, two of the charter members and most consistent in their support of the Society. He commented on the variety of technical papers but rather deplored the neglect by modern naturalists of the more literary aspects of their work, citing Kirby, White, Fabre, Beebe and others as examples of men who combined excellence of diction with a faithful account of their observations.

The business meeting was called to order at 11.30 A. M.

The minutes of the last meeting were read and approved.

The financial statement was read and approved.

The next item of business was the election of officers. Professor Lochhead, founder of the Society and for eighteen years President, announced his retirement on account of ill-health. Professor Maheux spoke in appreciation of the excellent service that Professor Lochhead had rendered, not only to our Society, but to Agriculture and education in Canada, particularly in the Provinces of Quebec and Ontario. He moved that Professor Lochhead be elected an honorary life member.

The following officers were elected for the year 1926-27:

President:—Rev. Father Leopold, La Trappe, P. Q.
Vice- President:—Dr. B. T. Dickson, Macdonald College, P. Q.
Secretary-Trasurer:—Dr. E. Melville, DuPorte, Macdonald College.
Directors:—C. E. Petch, Hemmingford, P. Q.
Prof. Father Louis Marie, La Trappe, P. Q.
A. F. Winn Esq., Montreal.
Prof. Bro. Victorin, Univ. of Montreal.
Prof. A. Maheux, Provincial Entomologist.
G. Bouchard, M.P., Ste Anne de la Pocatière.
Prof. J. Coulson, Macdonald College, P. Q.
Omer Caron, Esq., Department of Agriculture, Quebec.

Auditor:—Prof. J. G. Coulson.
Delegates to the Royal Society of Canada:—
The President and Vice-President.
Delegates to the Ontario Entomological Society:—
Prof. Lochhead, Dr. DuPorte and Father Leopold or Mr. Daviault
Delegates to the Canadian Branch of the American Phytopathological Society:—
Dr. B. T. Dickson, Rev. Father Leopold, Mr. O. Caron, and Prof. J. G. Coulson.
Delegate to International Plant Congress:
Dr. B. T. Dickson.

It was moved by Mr. Drayton, seconded by Prof. Maheux and approved that the Society meets the expenses of the delegate to the Plant Congress up to a sum not exceeding fifty dollars.

Prof. Maheux reported that he had discussed the matter of free separates to authors with the Deputy-Minister, who was not favourable to the idea, and suggested that the Society makes a private arrangement with the printers, The matter was still under consideration.

The Society moved a vote of thanks to Mr. Maheux for his work.

It was resolved that the Society as far as funds are available continue to help in aiding investigation concerning economic diseases caused by insects fungi or bacterial.

VIRUS DISEASES

B. T. Dickson

Something more than half a century ago the new field of work in the study of disease causation was in connection with "zymotic" diseases, or diseases caused by bacteria. Little was then known of their morphology, physiology and taxonomy, or of their pathogenicity. Today it is probably safe to say that bacteria are more completely known physiologically and taxonomically than any other group of micro-organisms.

We, in turn, are faced with congeries of diseases, the causes of which present difficult yet fascinating problems. I refer to the virus diseases, or to use the term suggested by Dr. L. R. Jones "viroses". There are now known viroses of man, of animals, of insects, of plants and of bacteria. It is in this field that plant, animal and human pathologists, perhaps more than in any other, may co-operate to mutual advantage. That is my excuse for writing a necessarily brief, general, compilatory article on viroses, concerning which I have first-hand knowledge of only one group.

It is of interest to note that while our confreres in other fields have far surpassed us in the intensity of their studies, for only within the last decade has widespread interest in plant viroses been awakened, yet to us belongs priority in demonstration. Dr. Erwin F. Smith, whose contributions to our knowledge of bacterial plant diseases are fundamental, studied and reported on "Peach Yellows" in 1888. showing then that the disease was transmissible by organic union and that to no bacterial or other micro-organism could the disease be ascribed. If we regard Peach Yellows as belonging to the viroses, then Smtih made the first study of a virus disease. I am excluding consideration here of the fact that variegation may be transmitted by grafting—a fact known much earlier—because no evidence is at hand that any etiological study was made, of such individual cases, which antedates 1888. To Ivanowski in 1892 is due the first demonstration of a filter-passing virus which again was in the case of a plant virose—tobacco mosaic. Ivanowski, however, neglected that phase of his study and inclined to the view of a bacterial causation so that to Beyerinck in 1898 is due the undoubted demonstration of the "virus" in tobacco mosaic as the etiological agency. It should be noted, in all fairness, that Pasteur in 1881 foresaw that the cause of rabies might be invisible as far as ordinary microscopy is concerned, but he did not demonstrate its filter-passing ability, this being done in 1904 by Remlinger and Riffat Bey. The work of Loeffler and Frosch in 1898 on foot and mouth disease was epoch marking and it was followed in rapid succession by studies on several important virus diseases of animals.

Characteristics of a virus.

At present it is possible only to suggest what may be regarded as properties or characteristics of viruses generally. With more detailed investigations greater accuracy of description will be reached and it is not unreasonable to hope that physiological studies will conduce to greater clarity of differentiation even though little may be visually poss ble.

1. Ultramicroscopic nature.

We are all familiar with the efforts made to see the virus—efforts usually ending in failure. This is due to the size of the constituent parts of the virus and hence the term ultramicroscopic as applied. Such a statement presupposes a corpuscular nature and does not therefore conform to Beyerinck's type of "contagium fluidum vivum".

Some have recently been demonstrated by special methods:—Pleuropneumonia of cattle caused by a coccoid organism just at the limit of visibility, *B. pneumosintes* causing influenza, Noguchi's globoid bodies in poliomyelitis, and the bodies demonstrated by Barnard and Gye in chicken sarcoma.

2. Filtrability.

That a virus can be filtered through porcelain filters which hold back bacteria is commonly regarded as a characteristic. It must be remembered that certain spirochaetes are able to pass through such filters and certainly such "organisms" as mentioned above. Filtrability is partly a function of size and it is likely also to be a function of the "structural" nature of the virus. If we postulate minute particles of proptoplasm as the virus it will pass through a filter of smaller pore than the diameter of the protoplasmic corpuscles. Concerning this some interesting work has been done since von Prowazek demonstrated that the virus of chicken plague can be held back by agar filters. Andriewsky in 1915 by using a graded series of agar filters concluded that the virus of chicken plague must be composed of corpuscles or aggregates about 25 u u and Duggar and Karrer in 1924 similarly showed that in tobacco mosaic the particulate size is approximately 33 u u—36 u u or about the size of the molecules of fresh haemoglobin.

Filtration of virus or of a composite does not, of course, mean that the filtrate will be a pure culture in the sense that only virus in a watery medium will be present in the filtrate. Obviously other particles of similar and smaller size will pass through the filter. If a disease is due to a combination virus, it is probable that both components will be present in the filtrate unless they are separable by gradation of filter.

The fact that by centrifuging for a considerable time, at a high speed, the virus of chicken plague and of rabies may be found at higher concentration in the lower levels of the filtrate is of interest in this connection.

3. Affinity for specific cells and tissues.

Whether or not every virus will be found to possess a specificity as to the

cellular medium in which it is pathogenic certain are quite definite in this respect.

Examples of this are rabies and the central nervous system, trachoma and the conjunctivae, vaccinia and the endothelium, foot and mouth disease and the mucous membrane of mouth and eyes, and I venture to include mosaic and the chlorenchyma. In this last the fact is established that the virus is found throughout a diseased plant but I am of the opinion that it is in the chloroplasts that the damage is done.

4. Intracellular parasitism.

To say that all viruses are intracellular parasites is to generalize on facts which are of necessity derived only from studies of diseases. Saprophytic viruses have not yet been found but they may, of course, exist. Even viruses as we know them may be dried or retained in dead tissues and still remain virulent for a varying period of time. It is possible too that some viruses may be present as commensals. Their intracellular parasitism renders them therefore extremely difficult to culture artificially. I have set up many hundred test tubes of various synthetic media and plant juices with and without traces of gelatin, agar, lymph, ascitic fluid, etc. and with and without sterile plant tissue but have not yet demonstrated that the cause of tobacco, tomato or potato mosaic will grow in such media. We are involved here in a question as to the animate or inanimate nature of viruses. There are many who hold to the view that Twort's bacteriolysin and D'Herelle's bacteriophage are inanimate viruses akin to enzymes, and Duggar suggests that in mosaic disease the causative agent may be a particle of chromatin or of some structure with a definite heredity that has revolted and being endowed with the capacity to reproduce itself continues to produce disturbance in the living cell in which it finds itself.

5. Unknown morphology.

This is in a sense a negative characteristic, but it is included here to bring into focus certain facts and suggestions. Even with such viruses as have been rendered visible nothing is actually known as to their morphology—we can only state that certain structures have been seen. Certain of these may be the causative agents and certain others cell reaction products. Thus Olitsky and Gates have demonstrated *B. pneumosintes* which may be I micron long, although usually less. It has been called Bacterium merely because of its shape. A minute coccoid body is described by Nocard and Roux for pleuropneumonia of cattle. Flexner and Noguchi isolated minute globoid bodies 0.15—0.3 u in the case of poliomyelitis, while Rosenow found a streptococcus which, grown anaerobically, gave minute forms. Lipschuetz proposed the name Stronglyoplasmata for visible viruses and in strongyloplasms division is by a process of median constriction giving dumbbell forms the daughter bodies of which gradually separate. In rabies the now well-known Negri bodies are found in the brain, in vaccinia there are Guarnieri bodies, Prowazek-Halberstadter bodies in trachoma and so forth. Von Prowazek in 1907 grouped such structures under the head Chlamydozoa suggesting that they were composed of minute granules

surrounded by a mantle furnished by the invaded cell. Intracellular bodies have been described in several mosaic diseases but it remains to be seen whether they are of the nature of those above described in spite of the fact that Palm has hurried to name the cause of mosaic *Stronglyloplasma ivanowskii*.

Part of the fascination in the study of such diseases is the attempt to obtain a mental picture of a causative agent which will comply with ascertained facts and mention has already been made of the suggestion of Duggar and of those holding to the view that it is enzyme-like. Simon in a recent paper says, in concluding a discussion of the taxonomic problem, "Theoretically there can certainly be no objection to the formulation of the hypothesis that disease producing agents of corpuscular nature may exist, which in part belong to the lowest forms of life, which are neither bacteria nor protozoa and in part to the higher forms of ferments, and that the main group of filterable viruses may properly find its position here rather than either amongst the bacteria or protozoa." Bayon suggests the name *microplasm* and subscribes to the following views:— "It is no idle hypothesis to surmise that viruses are not only extremely minute particles of protoplasm with the simplest structure compatible with life-that is the faculty of selective assimilation, secretion and with the power of successive, almost limitless multiplication—but that also they have hardly differentiated into cellular components, nucleus and ectoplasm and therefore they are extremely delicate and subject to damage by outside influences when isolated; the chlamydozoic mantle or shell being accordingly a necessary protective covering supplied by the nucleus of the cell host".

The recent work of Johnson with "virus" from presumed healthy potatoes giving rise to infectious diseases of tobacco falling apparently in the mosaic group is evidence that the first part of Bayon's suggestion is possible of vindication. Johnson concludes his published account by the statement: "The experimental results indicate that potatoes are either true carriers of viruses or that potato protoplasm is actually the causal agency of one or more virus disease of tobacco and other solanaceous plants".

*Since this address was given on April 15, 1926, at the 19th annual Meeting of the Quebec Society for the Protection of Plants, a very interesting paper has appeared in which Dr Eckerson (Bot. Gaz. 81: 204-209, 1926) illustrates protozoa in, and entering, chloroplasts of tomato, and also protozoa found in several other mosaic-diseased plants. In the same issue is a paper by Miss Purdy which concluded with the statement: "The writter has been unable to obtain any evidence that the active agent producing mosaic disease in tobacco and tomato plants multiplies outside the living plants".

6. Other characteristics.

With improvement on technique it follows that the determination of thermal inactivation points, adsorption phenomena, reactions to preservatives and viricidal substances, effects on host cell metabolism and so on will enable us more adequately to characterize any individual "virus".

VIRUS DISEASES OF THE POTATO

By Donald Folsom, B.A., M.A., Ph.D., Maine Agr. Exp. Statio ·.

In the report of this Society for 1916-17 I found a paper on "Physiological Diseases of Potatoes." It is of historical interest to note that it mentions leafroll, curly-dwarf, mosaic and streak; that it refers to the probability of these maladies remaining latent for several years and of leafroll being infectious; and that it recommends the grower to rogue, hill-select, and plant northern-grown seed.

The name "physiological diseases" could well be retained according to one viewpoint. That is, the virus diseases of potatoes are characterized in the literature by the behavior or effect of the causal agencies rather than by the structure of the latter.

In this paper a "virus" is considered to be any causal agency whose structure is unknown or which is filterable, and which apparently reproduces itself in the host plant. The value of this definition will be made clearer further on in this paper, when it will be discussed in relation to the problem of the recognition of new virus diseases.

The virus diseases that I shall describe can be listed in five groups according to their appearance or symptoms in the Green Mountain variety under the conditions under which we have studied them. The leafroll group includes leafroll and yellow-top. The mosaic group includes mild mosaic, rugose mosaic, leaf-rolling mòsaic, crinkle mosaic, and type V (as yet unnamed). Aucuba mosaic constitutes a third class, and streak a fourth. The spindle-tuber group includes spindle-tuber, unmottled curly-dwarf, and giant-hill, of which the last has not yet been definitely proved to be transmissible from plant to plant.

Such grouping of diseases may be taken to suggest the relationship of their viruses, each group of viruses presumably corresponding to a genus or possibly a family of fungi or bacteria. In a generic or family group of fungi or bacteria there is an intergradation as to morphological characteristics. Similarly there is an intergradation, as to symptoms, of these virus diseases, especially in each group. This is suggestive of corresponding intergradation n structural characteristics of the viruses.

I do not expect to exhaust the subject. Very probably there are other virus diseases of the potato and other groups of such diseases in addition to those considered here. This paper is based in part on experience which is very incomplete in the applications of histological, bacteriological and entomological technique, most of our studies so far being largely taxonomic and economic. Reference to the literature will be given only for the more interesting and debatable statements that are made, or for those for which the detailed evidence may be wanted by the student of the problem. *

*Some of the references cited contain limited but representative bibliographies.

Fig. 1.—Plant with leaf roll on lower leaves.

Fig. 2.—Tuber with outer part at stem removed to show net-necrosis, a symptom of leafroll under some conditions. The two holes were cut to remove rot.

Fig. 3.—Tuber cut across at stem end to show net-necrosis, a symptom of leafroll under certain conditions.

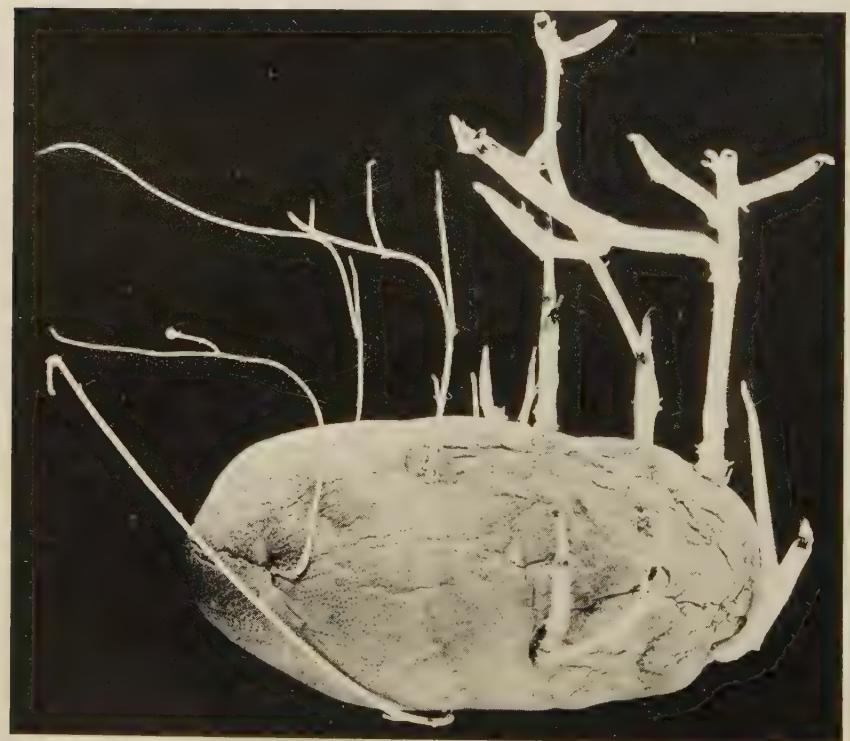

Fig. 4.—Tuber showing spindling sprouts resulting from net necrosis in stem-end half (at left in illustration).

At this point acknowledgment should be made of the generous cooperation by the United States Department of Agriculture, especially through Dr. E. S. Schultz, which has greatly hastened the arrival at such conclusions as have been reached in the course of the work in Maine.

Nomenclature

Too much space in the literature has been used for making pleas for the standardization of the names of virus diseases, apparently on the assumption that these names could be treated like Latin binomials subject to rules of priority. A virus disease in potatoes is merely a symptom aggregate that has an undescribed cause. The name of a virus disease therefore actually corresponds to the common descriptive names of diseases of other types, and so is primarily a matter of local usefulness. It is possible by means of appropriate methods to show that sometimes the symptom aggregate designated by one name is caused by the same virus as the symptom aggregate designated at another time and place by another name. When this occurs, it is claimed that confusion will result from adhering to both names of the one disease. On the other hand, instead of having two names for one disease, in some cases one name is given to two diseases. That is, a name and symptom aggregate in one potato variety in one environment is identical with a name and symptom aggregate described in another potato variety or in another environment, but two viruses are concerned, as can be shown by bringing them together in the same variety in the same environment. In this case rules of priority would demand the adoption of a new name in one place or the other. In either of these cases some confusion may result, from adhering to the present descriptive names, which will concern the scientists, but it will harm them less than the elimination or replacement of such names will harm the growers. In time standardization based on the symptom aggregates associated with certain standard sets of factors may result in the assigning of numbers as is done to bacteria or to the physiological races of a species of fungus. However, even then the standardizing number while possibly assisting scientists to coordinate their efforts better, will be too cumbersome or too unappealing to the imagination to be practical. In brief, I think that it at least is still premature to attempt to set up one name as being preferable for a given disease on the basis of priority inasmuch as the present names should be regarded as local descriptive names that correspond to the as yet undetermined names of the causal agencies, the latter alone being suitable subjects for discussions regarding priority.

There is also another advantage from this policy. Aside from the usual question of priority, that is, who first wrote a complete description of an organism, or, as it would be here, of a symptom aggregate, we would otherwise have a complication of the synonymy due alone to the variety of forms. As compared with certain rusts or aphids, with their puzzling synonymy due to the several forms on different hosts, some virus diseases of potatoes probably have still

more names by which they are known in different climates and varieties. These names will not have to be carefully listed as synonyms if rules of nomenclature are considered as properly belonging only to the differences between causal agencies with no reference to differences in symptoms.

Finally, I might add that demands for the standardization of the names of virus diseases come with poor grace from anyone who abandons the well-known name "mosaic" and adopts a new name "crinkle" for a type of mosaic, or from anyone who sets aside such a name as "streak" replacing it with another of his own although having no proof that the same virus was involved in the two places. It is often desirable to adopt new names for diseases in different regions, in fact, may be better in the absence of proof of the identity of the diseases, but those adopting new names are in an especially vulnerable position when suggesting that only one name be adopted universally. Whose name is usually suggested, can be easily conjectured.

Whether the group of diseases in question should as a whole be called physiological diseases, virus diseases,degeneration diseases, phloem diseases, or viroses* is probably dependent upon the customs, interest, and training of the audience and writer or speaker. As shown previously, the term "physiological" emphasizes the behavioristic nature of the differential characteristics of these diseases, as well as suggesting the enzyme theory of causation. The term "virus" and its derivative "viroses" refer to the hypothetical, as yet undescribed, causal agencies. "Phloem" as a general term has the advantage of emphasizing the place of entry of certain diseases under certain conditions of effective natural inoculation, but may possibly contain a misleading inference as to the distribution and extent of the virus and of symptoms. "Degeneration" while clumsy and not scientific to the ear, has appealed to us as being old, expressive to all classes of students including those learning in the school of practical experience, and descriptive of the symptoms as a whole, thus agreeing with our policy of regarding names as applying primarily to aggregates of symptoms. Also "degeneration diseases" is a term that brings out the perpetuation of the virus in succeeding generations through reproductive structures of the host plant, a characteristic which is not true of the virus diseases of many other plants.

Etiology

According to the definition given previously, in order to show that a symptom aggregate is probably a virus disease it is necessary either to secure negative results from the usual methods of detecting pathogenes with known types of stucture, or to prove the filterability of the causal agency, and in addition to show that the causal agency apparently multiplies in the host plant.

It is not proposed here to discuss the structure of filterable viruses. It is

*A Latin-Greek combination recently proposed by Dr. L. R. Jones at an international conference of workers in this field held at Lincoln, Nebraska.

sufficient to quote two extracts, the first being from Simon (17, p. 491-492) * as follows:

"To assume, on the basis of our present knowledge, that the filter passers are either bacteria or protozoa, is unwarrantable. We may say that certain observations suggest that a few protozoa, and possibly bacteria may assume a filter passing size, but so far as the great majority of the filterable viruses goes, there is no evidence whatsœver to warrant the claim that their taxonomic position has been established. It might possibly be best to classify them as protista, were it not for the fact that there is evidence to suggest that some of them may be inanimate, even though corpuscular. Theoretically there can certainly be no objection to the formulation of the hypothesis that disease producing agents of corpuscular nature may exist, which in part belong to the lowest forms of life, which are neither bacteria nor protozoa, and in part to the higher forms of ferments, and that the main group of filterable viruses may properly find its position here rather than either amongst the bacteria or protozoa."

Mention may also be made of the gene theory recently proposed by Duggar and Armstrong (2, p. 210):

"Taking into consideration all the facts, we cannot avoid the impression, tentatively, that the causal agency in mosaic disease may be, in any particular case, a sometime product of the host cell; not a simple product such as an enzyme, but a particle of chromatin or of some structure with a definite heredity, a gene perhaps, that has, so to speak, revolted from the shackles of coordination, and being endowed with a capacity to reproduce itself, continues to produce disturbance and 'stimulation' in its path, but its path is only the living cell."

A word is now necessary as to why my definition of virus diseases includes all symptom aggregates due to causal agencies whose structure is unknown, even when filterability has not been demonstrated, provided of course that they multiply in the host plant. In rugose mosaic of potatoes we have a disease obviously similar to tobacco mosaic but the filterability of its virus has not been demonstrated in spite of a number of trials with Berkefeld filters including those of the coarsest grade. However, the consistent inactivation by the Berkefeld candle has not convinced us yet that the virus is composed of particles too large to pass the pores of this filter.

Our hesitancy is due in part to tests of inoculum from different parts of the plant. In Maine, "leaf mutilation inoculations... were made on plants of the Green Mountain variety in the open field in 1923. The effect of taking the inoculum from different parts of the plant was tested with rugose mosaic... Inoculum from either the entire shoots, the stems and petioles, or the leaflets alone, was more effective than that from roots or tubers... Infectiousness here seems to be correlated with the presence of chlorophyll. Not only were the colorless parts far less infective, but the inoculum from the leaflets was more

*Reference is made by number to Literature cited, at the end of this paper.

infectious than that from the supporting parts of the plant. . . Also the inoculum from the leaflets was more infectious than that from the leaflets, petioles, and stems (aerial parts) combined . . ." (15, p. 505,507.)

In subsequent similar inoculations * a reduction in the amount of chlorophyll, effected by extracting the inoculum from roots and ungreened sprouts and tubers or by letting the inoculum stand for a day subject to putrefaction and settling, generally though variably reduced the virulence of the inoculum. After this partial putrefaction some of the inoculum was subjected to preliminary filtration through the sediment, suspended in it at first, but by this time easily held by filter paper as a gelatinous coating, to remove the most of the suspended materials, which would otherwise soon clog the pores of the Berkefeld filter candle. The latter, of course, removes the few remaining chloroplasts. We have not yet studied the effects of dilution by adding water or non-viruliferous extract. However, even when using a drastic method of inoculation low percentages of infection are sometimes got with the nonfiltered chlorophyll-free extracts referred to, indicating that the removal of chlorophyll by other means than Berkefeld filtration reduces the virulence enough to approximate the point where the dosage is insufficient. It seems possible that the further removal of chlorophyll by the Berkefeld candle merely reduces the dosage below the point of infectiousness, without removing all of the virus.

Accordingly the causal agency of rugose mosaic of the potato has not been shown to be filterable. Inasmuch as this disease has a shorter incubation period and a higher percentage of infection than the other virus diseases under normal conditions of inoculation, it was the first potato virus disease to be tested in this particular. These characteristics do not favor the expectation of proof of filterability with the other virus diseases, especially with leafroll which up to date has been transmitted only by means of grafting and insects. However they also will be tested as the marked limitations of season and space incident to this kind of work with potatoes permit.

Multiplication in the host plant is usually assumed to have occurred if inoculation either by contact of grafted surfaces, by applying a small amount of extract to freshly wounded tissues, by viruliferous insects, or by similar means, is followed by the appearance of the symptoms in other parts of the plant than those inoculated.

While there is record of leafroll, streak and mosaic having been tested as to the presence of a pathogene with a known type of structure, as a matter of fact the diseases of the spindle-tuber group have not been thus tested as far as I know. On the basis of transmissibility by the methods of inoculation referred to, together with the absence of macroscopic lesions, and with the evidence of multiplication in inoculated plants, it has been assumed that this group of diseases are in nature fundamentally similar to the other groups mentioned.

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*Performed in large part by Mr. Reiner Bonde, Assistant Plant Pathologist of the Maine Agricultural Experiment Station.

Fig. 5.—Tuber unit grown from a tuber with net-nectosis. The stem-end quarters were planted at the right and the bud-end quarters at the left. All four plants have leafroll, of which net-necrosis is a symptom under certain conditions.

Fig. 6.—Plant with yellow-top.

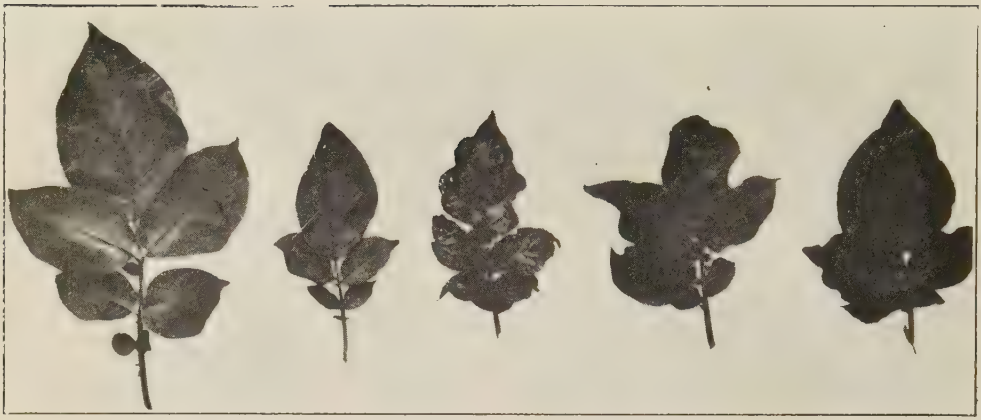

Fig. 7.—Five leaves taken from corresponding parts of the tops of five plants after four of the plants had been infected respectively with four kinds of mosaic. From right to left (with stems down): rugose mosaic, leafrolling mosaic, crinkle mosaic, mild mosaic, and healthy.

Fig. 8.—Mild mosaic plant (on right) of a strain known to be entirely mosaic from 1916 to 1923, inclusive, compared with a rugose mosaic hill of a strain infected in 1921. Photographed on September 10, 1923, after the death of the rugose mosaic plant.

In fact, however, there is room for considerable work attempting to demonstrate morphological evidence of the causal agency and attempting to isolate the virus *in vitro*, even though negative results be expected.

For practical purposes, when a new symptom aggregate such as spindle-tuber, yellow-top, or giant-hill is segregated and is both transmitted by the specified methods of inoculation and perpetuated indefinitely by the tubers, it is immediately added to our list of degeneration diseases and subjected to the control measures considered applicable to diseases of this kind.

The preceding discussion is concerned with the question as to whether a given symptom aggregate is to be considered a virus disease of potatoes. When this has been proved, it is another kind of problem, upon which work is then in order, to test whether the disease in question is like the others in stock.

The first step is to compare the new disease with the others in plants of one variety and in the same environment. This should be repeated in one or more different environments since two different diseases may resemble each other in certain environments. Comparisons should also be made in plants of different varieties, these serving as differential hosts. In one variety and in one environment diseases may be found to differ as to symptoms, as to the effectiveness of a certain method of inoculation, and as to the length of the incubation period between inoculation and the initial appearance of the symptoms.

When it is desired to learn whether a new disease is identical with another that has been described, the process often is complicated by the necessity of securing authoritative diseased plants from a region and in a variety different from those pertaining to the new disease in hand. If feasible, a comparison may be made of descriptions based upon the same variety grown in separated but standardized environments controlled as to soil moisture, soil temperature, air temperature, air humidity, and light (artificial). Even then the precaution is needed of getting the stock all from the same source because of the possibility otherwise of the variety in use having a masked disease or some other difference due to the source of seed, in one place but not in the other.

If this is done and the experimenters are convinced that the same disease is prevalent in two regions, the practical value of this conclusion will often be minimized by the differential effects of regional variations in climate, insect population and culture. The segregation and naming of the virus diseases of a potato region, which is work of fundamental importance, chiefly needs considerable study extending on the part of at least one worker through several seasons. It does not always require, and is not necessarily helped by, efforts to correlate the results with those reported elsewhere.

When a region has been completely worked over so that all the virus diseases are recognized in all varieties and under all environments, or before for that matter, further etiological work can be done on the properties of the viruses as brought out by more or less artificial conditions. Allard and others have paved the way in this respect working with certain more virulent virus diseases of small and easily grown crops. I have in mind, for example, the effect

of dilution, ageing, and various salts and acids upon the virus, and the rate of diffusion of the virus under different conditions. Especially important is the study of a virus in different insects. This is quite aside from the light such study will throw on the relation of dissemination to control, which will be discussed later.

Symptoms.

As far as our work is concerned, the most complete comparison of virus diseases has been made in the Green Mountain variety in Aroostook County, in the northeastern part of the State of Maine. Even this is rather incomplete. However, it will be presented in tabular form.

In the tables use will be made of certain symptomatic names which need some definition or description. "Dwarfing consists essentially of reduction in size of parts rather than in their number, although both may occur together. The supporting parts of the shoots and leaves are reduced in length and thickness. The leaf blades are reduced in area, possibly only apparently so sometimes when wrinkling or ruffling is present. Spindliness is lateral dwarfing, resulting in stems or tubers being abnormally slender. Chlorosis is a yellowing or paleness that affects the leaf blades and is assumed as being diffused unless designated as mottling. Mottling is a localized chlorosis consisting of spotting of the leaf blades by light green areas, which may or may not occur in contact with the larger veins, and which vary in shape and degree of paleness. These discolored spots are punctate, elongate, circular, angular and irregular. They vary from a barely discernible fading of the green to an almost pure yellow, often in the same spot. They seldom exceed a few millimeters in any dimension, and their distinctness of outline differs, usually in proportion to the degree of discoloration. They are more readily seen in diffused light than in direct sunlight. Wrinkling is an abnormal unevenness of the leaf-blade surface due to depressions and prominences not arranged in any uniform manner as is true with rugosity. Rugosity differs from wrinkling in having depressions only at the veins and in having the prominences of uniform height. Ruffling is an abnormal unevenness of the leaf-blade surface caused by ridges that develop or become more pronounced with passage from the midrib to the lateral margins, resulting in waviness of the margin. Curling is an abnormal bending of the leaf blade downward along the main vein. Rolling is an upward curving of the sides of each leaflet with the midrib at the bottom of the trough thus formed. Uprightness may appear in both leaves and stems but is assumed to be in the latter alone unless otherwise stated. It is characteristic of normal plants in most varieties when small and probably in diseased plants is often due to dwarfing. Rigidity may affect either stems or petioles, or both; brittleness may do the same. Necrosis is the premature death of tissues accompanied and manifested by their turning brown. It may appear as spot necrosis or spotting, with brown flecks of leafblade usually more conspicuous on the upper surface; or, as streak necrosis or streaking, with brown streaks first, most evident on the lower surface of the leaf veins but sometimes

Fig. 9.—On left, spindle-tuber plant from half-tuber seed piece, compared with healthy plant from quarter-tuber seed piece. Note in the latter the less upright habit of leaf growth and flatness of the leaf surface.

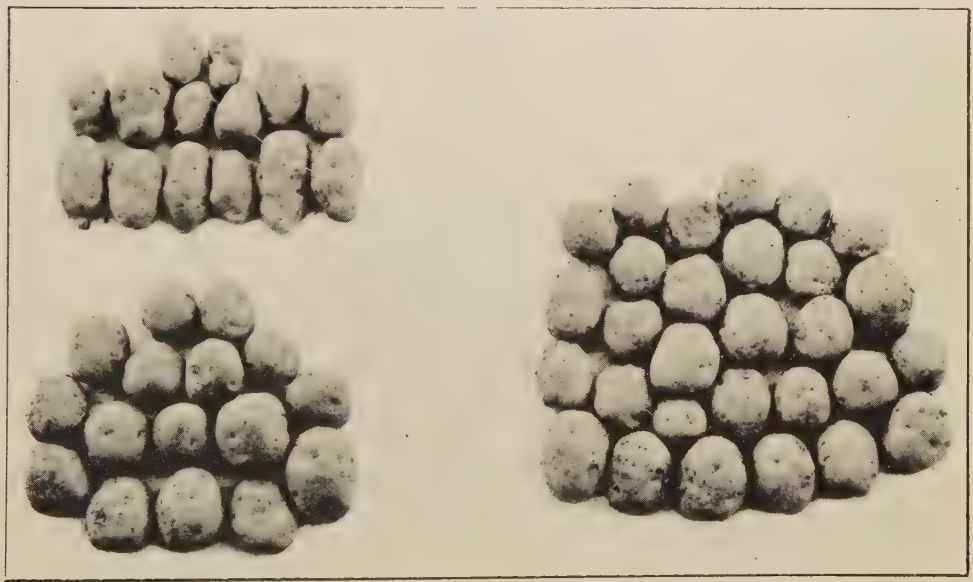

Fig. 10.—Tubers of the 1923 crop showing distance of spread of spindle-tuber in 1922. On right, representing 29 hills sampled in tenth healthy row distant from spindle-tuber-stock. On left representing 30 hills sampled in fifth healthy row distant from spindle tuber stock; here about half of the hills had become infected by the disease, which did not spread to the tenth row.

Fig. 11.—Tubers produced by plants with unmottled curly-dwarf.

Fig. 12.—In foreground, healthy plants. In background, bearing blossoms yet, giant-hill plants.

also apparent on the upper leaf surface, stems, and petioles; or, it may appear as marginal necrosis or burning, beginning at the margin and progressing inward. Streaking may spread out into parenchyma as spotting or burning. Leaf dropping concerns entire leaves, usually the lowest first, and then progressively higher ones. It may begin with a collapse of the green petioles, followed by wilting and finally by necrosis of the petioles and blades. Premature death usually is preceded by leaf dropping and necrosis and finally involves the whole stem and shoot." (16, p. 44-45.)

These symptoms as listed in the accompanying tables are not all to be seen at one time. Inoculation usually occurs in the field rather than in the bin. If it occurs early enough, is effective, and incubation period is short enough, there occur symptoms,usually restricted to the distal portions of the shoots or to the tubers, that are here designated as "inoculative" symptoms. The virus may or may not become distributed completely throughout all the parts of the plant. If it becomes completely "diffused" throughout a tuber the disease is perpetuated and all the progeny of the tuber grown during the next season or in the next plant-generation display "perpetuation" symptoms. Inoculative symptoms often are distinctly different from perpetuation symptoms. Inoculative and perpetuation symptoms have been designated in Europe respectively as primary and secondary symptoms, and in American sugar cane regions, even in reference to potatoes, are known reversely as secondary and primary symptoms (3, p. 7).

In some instances incomplete diffusion in the tuber before the beginning of the dormant period is followed by a resumption of the diffusion after the next season's planting, and as the virus invades the originally healthy shoots there may result symptoms identical with inoculative symptoms. They may in fact be considered essentially as such, the inoculation being effected by the entrance of the virus itself instead of by its introduction through agencies external to the plant.

In spindle-tuber the first perpetuation symptoms are shown by plants grown from tubers infected too late to influence their shape. They often are less severe than the perpetuation symptoms of succeeding generations of plants grown from tubers showing the symptoms. Apparently in association with the emergence of the tuber symptoms there is a change for the worse in other respects. In leafroll, on the other hand, the inoculative symptom net-necrosis induces much more severe perpetuation symptoms in the first subsequent generation than occur afterwards. Mosaic, contrary to frequently expressed beliefs, does not increase in severity with succeeding generations, although it may appear to do so either in correlation with seasonal or climatic depression of yields or because of the addition of unrecognized other virus diseases. We have now grown one mild mosaic stock for ten seasons, with no progressive diminution of vigor and with much less diminution than has resulted from the first perpetuation symptoms of rugose mosaic.

Except for yellow-top, it is chiefly the perpetuation symptoms that are

brought out in the tables. Blank spaces in the tables signify either absence of symptoms, absence of information, or more specific description elsewhere. Revision of these tables may be needed later as some of the newer diseases become more familiar to us. The illustrations accompanying this paper may be used to supplement the tabular list of differential characteristics.

DIFFERENTIAL CHARACTERISTICS OF CERTAIN MOSAIC DISEASES OF GREEN MOUNTAINS IN NORTHEASTERN MAINE.

Name	Mild mosaic	Crinkle mosaic	Leafrolling mosaic	Rugose mosaic	Aucuba mosaic
Dwarfing	Slight	Slight	Slight	Distinct	
Spindliness	Absent or very slight.	Absent or very slight.	Absent or very slight.	Slight.	
Chlorosis				Distinct in plot.	
Mottling	Distinct, spots angular or irregular.	Distinct	Indistinct	Distinct	Lemon yellow round spots.
Wrinkling	Present	Distinct	Slight	Rugosity.	
Ruffling	Present	Distinct	Present, especially as inoculative symptom.	Inoculative symptom.	
Rolling			Present	Ditto.	
Curling				Ditto.	
Leaf texture	Tender	Tender	Tender	Slightly stiff, tender.	
Uprightness.					
Rigidity.					
Brittleness of stems and petioles.				Inoculative symptom.	
Streaking				Ditto.	
Spotting				Ditto.	
Burning				Ditto.	
Leafdropping				Ditto.	
Premature death	Slight	Slight	Slight	Distinct.	
Tuber symptoms					
Effect on yield	20 per cent reduction.	Like mild mosaic.	Like mild mosaic.	50 per cent reduction.	
Response to temperature.	Obscured by high.		Obscured by high.	Obscured by low.	
Difference between inoculative and perpetuation symptoms.			Present	Distinct.	
Inoculation by:					
Grafts	Effective	Effective	Effective	Effective	Effective.
Leaf-mutilation	Possible	Possible	Possible	Easy	Possible.
Aphids	Effective	Effective	Effective	Effective.	
Incubation period	Usually over 25 days.	Like mild mosaic.	Intermediate	About 14 days.	
Diffusion of virus	Rapid and usually complete.	Ditto	Ditto	Slow and often incomplete.	
Natural increase in region.	Sometimes rapid.			Slow.	
Regional prevalence	Common	Rare	Rare	Rare	Absent outside plots.

DIFFERENTIAL CHARACTERISTICS OF CERTAIN NONMOSAIC VIRUS DISEASES OF GREEN MOUNTAINS IN NORTHEASTERN MAINE.

Name	Streak	Leafroll	Yellowtop	Spindle tuber	Unmottled curly-dwarf	Giant-hill
Dwarfing	Extreme	Distinct	Distinct	Distinct	Extreme	Overgrown.
Spindliness	Extreme	Often distinct especially in sprouts.	Like leafroll.	Distinct	Extreme	Overgrown.
Chlorosis	.....	Often distinct	Extreme at times.	Darker green.	Darker green.	Slight.
Mottling	Slight preceding necrosis.					
Wrinkling	Distinct	.....	.....	Slight or absent.	Distinct.	
Ruffling.						
Rolling	.....	Distinct	Distinct at times.	Slight or absent.	.....	Slight or absent.
Curling	Extreme	.....	.....	.....	Extreme.	
Leaf texture	Very tender.	Stiff, leathery	Stiff	.....	Tender	
Uprightness	Extreme	Distinct	.....	Distinct	Distinct.	
Rigidity	Distinct	Distinct.				
Brittleness of stems and petioles	Extreme.	.....	.....	.....	Distinct.	
Streaking	Distinct	.....	.....	.....	Occasional.	
Spotting	Distinct	.....	.....	Occasional	Occasional.	
Burning	Extreme	Distinct	.....	Occasional	Occasional.	
Leafdropping	Extreme	.....	.....	.....	Occasional.	
Premature death.	Extreme	Distinct	Distinct	Longer-lived	Distinct	Longer-lived.
Tuber symptoms	Browning near eyes.	Net-necrosis as inoculative.	Net-necrosis sometimes, many small ones.	Spindling, cylindrical, pointed, eyes shallow and prominent, skin thin, flesh brittle at harvest.	Like spindle-tuber and also growth cracks lengthwise.	Sometimes like spindle tuber as to shape.
Effect on yield	100 per cent reduction after inoculated generation.	40 per cent reduction.	.....	20 per cent reduction.	60 per cent reduction.	Slight reduction to slight increase.
Response to temperature.	Intensified by high	.....	.....	Slightly frost resistant.	.....	Distinctly frost resistant.
Difference between inoculative and perpetuation symptoms.	Distinct	Present in tubers.	As for leafroll.			
Inoculation by:						
Grafts	Effective	Effective	Effective	Effective.		
Leaf-mutilation	Easy	Impossible	.....	Possible	Easy.	
Aphids	Effective	Effective	.....	Effective	Effective.	
Incubation period.	12 days	Like mild mosaic.	.....	Like mild mosaic.	Like mild mosaic.	
Diffusion of virus	Rapid and complete.	Slower than mild mosaic.	.....	Like mild mosaic.	Like mild mosaic.	
Natural increase in region.	Slight in plots	Self-eliminating.	Slow	Sometimes rapid.	Slight in plots	Slow.
Regional prevalence.	Absent outside plots.	Only in few imported stocks.	Only in few imported stocks.	Common in native stocks.	Absent outside plots.	Only in imported stocks.

It may be suggested again here that the study of this group of diseases may best be planned as a long-time piece of work, even in view only of the large number of symptoms together with their perplexing intergradation. Two diseases may appear similar early in the season and become differentiated later. Seasonal masking or modification of symptoms sometimes occurs. Combinations occur which in time can be analyzed or broken up by the transmission of one disease without the other, or which can be duplicated in other plants by inoculating the same healthy plants with the two or more viruses of the combination. The severity of injury by a combination is sometimes greater than the sum of the injuries by the separate diseases.

As indicated previously, our work is incomplete especially in regard to microscopic symptoms and the influence of the virus diseases on physiological processes aside from that of reproduction by tubers. It seems probable, however, that such work will be more valuable when preceded by definite distinction and segregation of the individual virus diseases. The methods of segregation found successful in northeastern Maine will be described later with reference to control.

The preceding discussion of symptoms is concerned with their study in one variety. Enough is known from intervarietal transmission to show that a similar long-time study should be devoted to each variety in any region. Of course it may help somewhat to learn that certain symptom aggregates in a new variety are due to the same viruses as have been studied already in a more familiar variety.

A comparison of varieties by means of cross-inoculations has shown that a given variety may be immune to one or more virus diseases. It then follows that a distance rule in potato seed certification should differentiate between varieties and diseases, being unnecessary in certain instances. For example, Irish Cobblers are not endangered by being grown next to mild mosaic Green Mountains.

A variety also may carry a virus with the symptoms obscured. This also is of importance in certification. For example, Green Mountains may be in danger from nearby Irish Cobblers that appear healthy but are actually infected with leafrolling mosaic.

The obscuring of certain diseases in certain varieties is of importance in attempts to compare varieties, strains of a variety, and hills of a strain. Very probably differences that have been disclosed between supposedly healthy varieties, strains, and hills, have often been due to differences in infection by certain virus diseases that are usually obscured. Our experiments have shown, for example, that Rurals can be infected with leafrolling or mild mosaic from Green Mountains, and healthy stocks of the latter then back-infected from the Rurals, with faint symptoms noted by us in the Rurals for only a few days of favorable weather during an entire season of careful watching. Consequently it is difficult for me to admit that any hill selection, strain testing, or variety testing that has been reported so far is free from the possibility of the influence

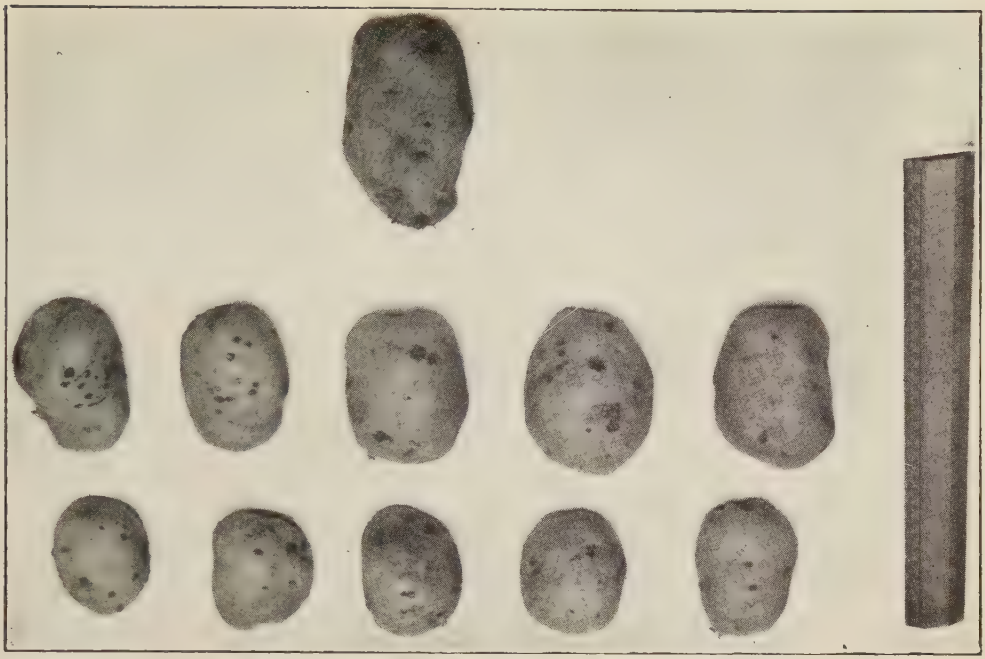

Fig. 13.—Largest tuber produced by giant-hill plant in 1924. This tuber was planted uncut and produced hill containing the other 10 tubers. Note the less marked symptoms of the 1925 season.

Fig. 14.—Sprawling plant with rugose mosaic. Upright plant with a combination of rugose mosaic and spindle tuber. In foregound, tubers from the two hills.

Fig. 15.—On left plant with streak, following perpetuation in the tubers. On right, healthy leaf. Leaflet and remaining leaf show spotting, streaking, and burning of streak, resulting from the recent inoculation of a healthy plant.

Fig. 16.—Upper part of plant with leafdropping associated with spotting, streaking and burning as a symptom of streak, resulting from the recent inoculation of a healthy plant.

of undetected disease upon the results. Of course, if hill selection on the basis of yield actually succeeds in permanently improving a stock, for practical purposes it is of no matter whether disease is originally present or not. On the other hand disappointment sometimes threatens, or occurs with a consequent wasting of time and effort, because differences seen during the first comparisons subsequently disappear due to the spread of obscured diseases to the originally healthy, high-yielding lots.

The question may be brought up now as to what assurance there may be that apparently healthy stocks of any variety in any environment are necessarily free from viruses. Force is given to this question by recent work by Atanasoff (1), Schultz (14) and Johnson (11). This concerns all work with apparently healthy potatoes. It has been concluded by Johnson that at least one masked virus can be made much more virulent by passage through a different host plant, tobacco. Even so the presence of the virus in potatoes originally, even in a mild form, might cause a slight difference such as is brought out in some hill selections and strain comparisons, so that a scientific interpretation of any results got from such work requires the incidental inoculation of differential host plants.

Influence of climatic and edaphic factors

Probably every virus disease has been attributed to the direct influence of climatic or edaphic factors previous to the acceptance of the demonstration of its infectiousness. There is some excuse for this. The climate of a region has a great effect on the kinds of virus diseases present and on the percentage of incidence of each. This effect is exerted in part through varietal preferences of the trade together with varietal susceptibility, and through other more or less artificial conditions. However, even these factors are probably dependent more than is realized upon the effect of the climate on symptoms, including yield, and on the spread of disease.

Climatic factors may obscure or accentuate certain symptoms. Recent work under controlled conditions has been done by Goss and Peltier that is of interest in this respect, showing that air temperature may be more important than light, soil moisture, and soil temperature (8, 10). As the result of climatic influence on symptoms, rugose mosaic may appear common and destructive in native stocks in a hot climate where mild mosaic is obscured. This leads growers there to fear "mosaic". Then when they go for seed to a northern region where the comparatively harmless mild mosaic is conspicuous and the rugose is rare, they may become needlessly alarmed at the mild mosaic. On the other hand, we are told that giant-hill may have little effect in a northern region but may greatly reduce the yield in more southern climates. In this case the southern buyer may need to disturb the complacency of the northern grower.

The interpretation and intelligent comparison of the seed certification rules of different political areas requires the consideration of the effect of climate upon symptoms. This effect is of importance in regard to certification also because

of the resulting need for following up approved stocks to see whether a greater allowance could be made of certain diseases that are obscured and relatively unimportant in seedbuying regions. Or, on the other hand, such following up may show that there is too great tolerance of certain diseases that are not severe in the certifying region, or that important diseases are obscured in the certifying region. In the last instance use may be made of examinations made in the earlier, southern climate in advance of the time of planting in the North.

The preceding applies to symptoms. There may also be an important climatic effect upon the spread of any disease in the same variety in different regions. "Comparatively healthy commercial stocks of five varieties divided and grown in four regions mostly next to diseased rows, with the progeny all grown in one place, showed that mild mosaic spread more in Virginia and on Long Island than in southwestern and northeastern Maine; that rugose mosaic was contracted markedly in Virginia but not elsewhere; that leaf-roll spread more farther south; that spindle tuber increased more in Virginia than elsewhere; and that the total disease percentage increased most in Virginia and least in Maine". (15, p. 528). This regional effect on spread may be direct, acting on the virus or host in some way as yet not understood, or may be indirect through determining the prevalence of weed and insect carriers.

Geographic distribution and prevalence

Preceding statements indicate that with the occurrence of varietal modification of symptoms and susceptibility, and with the occurrence of regional differences in varieties and even in the behavior of one disease in one variety, it will be difficult to draw reliable conclusions from records made by different people in different regions. In Maine in Green Mountains it seems that conditions are unfavorable to leaf-roll in the northeastern part. Spindle-tuber seems to find conditions favorable for spread and perpetuation throughout Maine, but is at least very rare, if not absent, in stocks imported from certain provinces further to the east. On the other hand, certain other diseases in northeastern Maine are limited to stocks imported from the same provinces referred to.

The prevalence of certain more common virus diseases, especially mild mosaic and spindle-tuber, in northeastern Maine has been greatly reduced in the last five years by the multiplication and use of comparatively healthy stocks. This is thought by some to have resulted in part from a recognition of the fact that these symptom aggregates are not due to climate and are not recovered from, but are due to diseases that are perpetuated indefinitely. Also, a selling premium on disease-free stocks and better results from them as to yield and quality have played some part in bringing about the change.

Control

The benefits of the control of a disease depend, of course, upon its percentage of incidence, its effect upon the yield rate, and its effect upon the price

Fig. 17.—Seedling plants leaflet showing streaking consequent to inoculation with juice from an apparently healthy Green Mountain plant. Other leaflet a healthy control.

Fig. 18.—Leaf with the Aucuba type of mosaic.

received for the crop. Certification and other conditions relating to seed prices may sometimes be such as to result in one field being injured more in regard to yield than another field while at the same time bringing more financially, all through differences in virus diseases. As the result of field tests as to yield reduction and of surveys as to the prevalence of disease, it was concluded several years ago that "in many apparently good fields, at least 10 per cent of the possible gross yield is lost through degeneration diseases. Therefore if planted instead with healthy seed, only nine-tenths of the acreage in such cases would be required to produce the same amount of crop." (6, p. 2.) As shown already, this conclusion would vary with time and region.

The tables of differential characteristics given in this paper contain some approximate percentage figures relating to the reduction in yield by certain diseases. These are based on field-plot tests. Such tests, of course, involve the careful consideration of field technique, especially where the soil is variable and the rate of fertilizer applied is high. Hill-selection tests are inadequate because the effect of a disease on yield is exaggerated in diseased hills grown in competition with healthy hills. Hand work may be undesirable also because of its minimizing the influence of certain commercial practices upon the effects of some diseases. For example, spindle-tuber stock suffers from machine planting and machine digging because of the tenderness of the flesh of the tuber. It is more convincing to have diseased and healthy lots descendant from the same healthy stock or at least from the same strain. It is desirable also to have the diseased and healthy lots coming from the same environment, but if this is done usua ly some of the selected healthy stock has become infected and gives diseased proeny in part in the yield-comparison tests. It is hard to determine whether the effect of a disease is proportional to the percentage of incidence in the plot. The question also arises whether healthy stocks grown in comparison with adjacent diseased lots suffer in yield as the result of infection occurring during the season of the test and occurring too late usually to be detected. Current-season infection by leaf-roll did not affect the yield in tests conducted in Indiana (7) and Great Britain (19).

The control of virus diseases involves their spead from one region to another, from one farm to another, from one field to another, from one plant to another, and in some instances from one part of a tuber to another (5). If a grower desires for one reason or another to reduce the amount of virus diseases in his stocks, he may make use of a certification agency to select his seed or he may depend upon himself. Probably the most successful growers are at the present time either selecting their seed in regions from which by experience they are led to expect consistently good stock under certain conditions, or are following a seed-plot method of which the latest development is the rogued tuber-unit seed-plot (4).

This kind of seed-plot contains hills grouped according to origin, each seed-tuber being planted in consecutive hills. The basic principle is that usually a tuber is entirely diseased or entirely healthy. The chief advantages of this

method, especially when gaps are left between successive units, are greater ease of detecting and removing diseased hills, and comparative concentration and limitation in number of points of origin of infection. It requires limitation to one variety in each plot, to be most effective.

With the use of the seed-plot is associated the problem of dissemination, involving that through knives (9), soil (18, 19) and aphids and other insects (12, 13). The extent of dissemination occurring during the season of selection or roguing is extremely important, but can be determined at present only by growing and observing adequate samples of the stocks in question in advance of the planting season. Dissemination from one hill to another in the same field or seed-plot is of greater magnitude in northeastern Maine than dissemination from one field to another. "In 1922, thirty-five fields were sampled in a study of the amount and distance of spread of mosaic and spindle-tuber from diseased to healthy fields. The samples, grown in 1923, showed that in 1922 one or both diseases had spread, in some places having done so enough to infect half the plants in the first five healthy rows next to diseased rows, and in other places spreading across the healthy field as far as the fortieth or fiftieth row." (6, p. 1).

Although the spread from one field to another may have been overemphasized in the past, a seed-plot should be isolated as far as possible. This is especially true of one planted with a tuber-line originating from a single seed tuber and never grown, since its origin, near to another stock of potatoes. The tuber-line method, while slow, is probably the most dependable one for developing a disease-free stock, assuming of course that diseases can be recognized at the first when only one tuber-unit constitutes a seed-plot. Isolation involves consideration of the possibility of volunteers from preceding crops.

In order to carry on experimental work, stocks with but one disease must after their segregation, be propagated from year to year. For this also we use tuber-unit seed-plots. Because of the large number of lots, however, it is necessary to be satisfied with a smaller degree of isolation, the various disease plots being separated by healthy buffer stocks. In the most critical experimental work the origin of each seed-tuber is a plant grown in an insect-proof cloth cage.

It may be pointed out here that in spite of incompleteness of control by the best field method known at present, that is, the tuber-unit seed-plot, this method is at least helpful. It can be used with tests of the effects of selection, maturity, soil, continuous fertilizer treatment, spraying, etc., uponthe v igorof healthy seed.

While true seed only rarely perpetuates these diseases, control by breeding new or resistant varieties is not in immediate prospect.

Conclusions

The only general conclusions that I wish to present are that the virus disease problem is still one in need of considerable research, and that it is a complex problem demanding detailed work in each important potato-growing region.

Literature cited

(1) Atanasoff, D. New studies on stipple-streak disease of potato. Phytopathology 15: 170-177, 1925.

(2) Duggar, B. M., and Joanne Karrer Armstrong. Indications respecting the nature of the infective particles in the mosaic disease of tobacco. Ann. Missouri Botan. Gard. 10: 191-212, 1923.

(3) Edgerton, C. W., and G. L. Tiebout. The mosaic disease of the Irish potato and the use of certified potato seed. Louisiana Agr. Expt. Sta. Bull. 181, 1921.

(4) Folsom, Donald, and E. S. Schultz. Methods of conducting the seed plot and its importance in potato improvement work. Proc. 12th Ann. Meeting potato Assoc. Amer. 1925. In press.

(5) Folsom, Donald, and E. S. Schultz. Methods to be observed to prevent spread of virus diseases in potatoes grown for seed stock. Proc. 11th Ann. Meeting Potato Assoc. Amer. 1924, p. 20-26, 1925.

(6) Folsom, Donald, and E. S. Schultz. The importance and natural spread of potato degeneration diseases. Maine Agr. Exp. Sta. Bull. 316, 1924.

(7) Gardner, Max W., and James B. Kendrick. Potato leaf roll in Indiana. Indiana Agr. Exp. Sta. Bull. 284, 1924.

(8) Goss, R. W. Effect of environment on potato degeneration diseases. Nebraska Agr. Exp. Sta. Res. Bull. 26, 1924.

(9) Goss, R. W. Transmission of potato spindle-tuber disease by cutting-knives and seed piece contact. (Abst.) Phytopathology 16: 68-69, 1926.

(10) Goss, R. W., and George L. Peltier. Further studies on the effect of environment on potato degeneration diseases. Nebraska Agr. Exp. Sta. Res. Bull. 29, 1925.

(11) Johnson, James. Transmission of viruses from apparently healthy potatoes. Wisconsin Agr. Exp. Sta. Res. Bull. 63, 1925.

(12) Murphy, Paul A. Investigations on the leaf-roll and mosaic diseases of the potato. Jour. Dept. Agric. Ireland 23: 20-34, 1923.

(13) Murphy. Paul A. On the cause of rolling in potato foliage; and on some further insect carriers of the leaf-roll disease. Scien. Proc. Roy. Dublin Soc. n.s. 17: 163-184, 1923.

(14) Schultz, E. S. A potato necrosis resulting from cross-inoculation between apparently healthy potato plants. Science 62: 571-572, 1925.

(15) Schultz, E. S., and Donald Folsom. Infection and dissemination experiments with degeneration diseases of potatoes. Observations in 1923. Jour. Agr. Res. 30: 493-528, 1925.

(16) Schultz, E. S., and Donald Folsom. Transmission, variation , and control of certain degeneration diseases of Irish potatoes. Jour. Agr. Res. 25: 43-117. 1923.

(17) Simon, Charles E. The filterable viruses. Physiological Reviews 3: 483-508, 1923.

(18) Whitehead, I. Transmission of leaf-roll of potatoes in N. Wales during 1921. Rpt. Internat. Conf. Phytopath. and Econ. Entom. Holland, 1923. p. 147-149. H. Veenman & Sons. Wageningen, 1923.

(19) Whitehead, T. (*sick*) Potato leaf-roll and degeneration in yield. Ann. Appl. Biol. 11: 31-41. 1924. As abst. in Bot. Abst. 14: 705. En. 4632. 1925.

PLANT PROTECTION IN RELATION TO THE INTRODUCTION OF FOREIGN DISEASES

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An important phase of plant protection work in Canada is the safeguarding of our plants from diseases which may be introduced from other countries, and at the same time raising the standard in quality of the nursery stock which is permitted to enter the country, so that the importer receives the best possible material.

This work is performed jointly by the Division of Foreign Pests Suppression of the Entomological Branch and the Division of Botany. I will describe how this service is organized and the difficulties with which we are confronted,

in the hope that it may stimulate a constructive discussion, for, as the name of our society implies, we are all interested in the protection of Canadian plants

Under the jurisdiction of the Destructive Insect and Pest Act, and by means of the money voted by Parliament for the carrying out of the regulations under this act, an inspection staff, under the direction of Mr. L. S. McLaine, chief of the Division of Foreign Pests Suppression, operates at St. John, N. B., Montreal, Que., Ottawa, Ont., Niagara Falls, Ont., and Vancouver, B.C., which are designated in the act as "ports of importation". The inspectors are responsible for the examination of shipments of plants and plant products from other countries, as well as shipments of this kind going from Canada to countries which demand certificates of inspection. All importations of nursery stock are made by means of a permit issued by the Destructive Insect and Pest Act Board of the Department of Agriculture.

When an inspector finds any form of deterioration in a shipment of nursery stock,he sends specimens of it to Mr. McLaine together with the necessary information for the identification of the shipment and the percentage of the trouble found. If this deteriotation is not primarily of insect origin, the specimens are sent to the Division of Botany with a form in duplicate stating the number of the permit under which the importation was made, the names of the consignee and consignor, and the percentage of the shipment affected. Two spaces are left on these forms for us to fill in—what we consider is the cause of the deterioration and whether the shipment should be admitted or not.

Firstly, I should like to describe what the diagnosis of these troubles entails. Most plant pathological work is confined to a study of the diseases of growing plants, but the diagnosis of the deteriorations of plants and plant products after storage and transportation opens up a new field, and one which presents many difficulties. The National Perishable Freight Committee of the United States have published from their headquarters in Chicago a splendid circular entitled "Plant Diseases of Importance in the Transportation of Fruits and Vegetables". In the diseases described there are many of the well known ones, which occur in the field, and carry on their depredations in the stored product, but there are others which are unknown except during the storage or transportation of those products.

Of the large amount and variety of material which we have examined since the inception of this service, while there has been a small quantity of fruit and vegetable material, the greater proportion of it has consisted of ornamentals, principally gladiolus and begonia corms; tulip, hyacinth, daffodil, and lily bulbs; dahlia and peony tubers; and iris rhizomes.

I have purposely referred to the troubles which we find in these specimens as deteriotations rather than diseases, for, while the plants grown in the other country may have been diseased, with the parasite continuing its activities in storage and responsible for the deterioration, yet the harvested product may have been injured mechanically when being dug, it may have been exposed to injury by heating or wetting when being cured, it may have been exposed to

heating, drying, wetting or asphyxiation when in storage or on the ship or train, and finally the specimens selected by the inspector, may have been subjected to mechanical injury or freezing on their way through the mails to our office. To make matters worse, practical y all the forms of deterioration from these sources are followed by the copious development of saprophytic fungi and bacteria, which successfully mask the primary cause, when the material is examined microscopically and by cultural means. After all these possible mishaps we are asked to diagnose the cause of the deterioration, so that, in case the shipment is refused entry, the importer can make a legal claim against the shipper, the transportation companies, or the insurance company which pays damages for stipulated forms of injury. Needless to say, you can understand how difficult this is when there is insufficient evidence for a definite diagnosis.

The study of the diseases of ornamental plants has up to the present received little or no attention as compared with that given to the diseases of other economic plants, and in addition, the diseases found in imported nursery stock are of foreign origin, are not always found in locally grown stock, and have, therefore, never received any attention by our division. An excellent publication has recently been issued by the United States Department of Agriculture through the Federal Horticultural Board entitled, "Foreign Plant Diseases" by John A. Stevenson, in which is given an annotated list, by host plants of parasitic fungi and bacteria occurring in other countries, and new or not widely distributed in the United States. This list will be of great use in this work.

From the annual and quarterly letters of information published by the U. S. Federal Horticultural Board, in which all entomological and plant pathological interceptions are listed, I chose the host plants tulips, narcissi, hyacinths, peonies, irises, and gladioli, and the countries France, Germany, and Holland. From nineteen copies of this publication covering a period of eight years, the following diseases were listed:

Tulips—*Botrytis Tulipae, Botrytis parasitica.*
Narcissi—*Penicillium* sp., *Botrytis parasitica.*
Hyacinths—*Aspergillus niger, Penicillium* sp., *Mucor* sp.
Peonies—*Mucor globosus.*
Iris—*Botrytis parasitica, Sclerotium* sp., *Fusarium* sp., *Penicillium* sp., *Vermicularia liliacearum.*
Gladioli—*Penicillium* sp.

Among the insects, eel worms, the narcissus fly, the lesser bulb fly, and mites are mentioned.

The list of diseases may be analysed in this way:

Botrytis Tulipae and *Botrytis parasitica* are now regarded as identical and the cause of the well known Botrytis blight of tulips. The remaining fungi named are invariably found in any form of decaying vegetable matter.

Knowing that there were plant pathologists in Holland, who, I understand, devote most of their time to the study of bulb diseases and training of inspectors for this service, I sent three lots of specimens, to Doctors Van Slogteren and Van Poeteren, with the statement that these specimens were taken from shipments received from Holland and that we would be glad to have their opinion as to the causes of the deterioration.

The first specimens were diseased gladiolus corms, with which I sent a culture obtained from this material, identical with the fungus causing the dry rot disease. Although more than a year has passed, no reply has been received.

Two samples of narcissus bulbs were sent later; the reply to the first of these was that the bulbs arrived in too dry a condition to permit them giving a well based opinion as to the cause of the deterioration, and the reply to the second was that some narcissus fly was present, and that the bulbs were apparently injured by a digging tool.

From these possible sources of information, therefore, our knowledge of the causes of these deteriorations has in no way been increased.

One interesting case occurred last summer in which an Ottawa firm imported a large number of daffodils from one of the Dutch houses. When examined by the inspector in Montreal they were in perfect condition. During the sale of these bulbs, the contents of two of the cases started to decay rapidly and specimens were submitted to us. We were at a loss to diagnose the trouble although a sclerotium-bearing fungus was isolated. I showed these specimens to a representative of a Dutch bulb firm and he recognised the trouble as a so called "ball rot", which he claimed was the result of sun scorch caused by the bulbs having been left on the surface of the soil longer than usual with rainy weather intervening, the resultant injury only becoming evident 6 weeks to two months afterwards.

In many cases, of course, the diagnosis is simple, and I can, without hesitation, make a report which could be used as a basis for a claim. I am attempting to improve my knowledge of this work by a careful record of all the specimens I examine, preserving the specimens after they are examined and cultured, and by following each case up as far as time permits. The whole subject however, requires painstaking research by someone who has sufficient time to make a thorough investigation, which could form the basis of a guide to inspectors at the ports of entry. Such a guide should contain detailed descriptions of the symptoms and causes of these troubles, with accompanying photographs, and instructions as to the method of dealing with the shipments having such troubles.

Having discussed the diagnosis of these deteriorations, we are left with the question of what should or should not be admitted, here again we are confronted with a difficult problem. The Destructive Insect and Pest Act is wide in its application, and, under its regulations, admittance may be refused

to any material showing any form of deterioration which renders it worthless, but the difficulty is to define the standards for such rejection.

Bulbs and other ornamental plant stock are imported by two classes of customers, viz:

1. Those who grow bulbs for immediate bloom or sale in bloom.
2. Those who import various types of bulbs and planting stock, notably gladiolus, peonies, and iris, for propagation and later sale.

In the former case we could perhaps be more lenient, for, suppose that a standard for rejection of three per cent was established, and that a shipment of tulips, narcissi, and hyacinths was rejected. The firm exporting these bulbs may or may not make good this loss, but in any case there is never time to replace the bulbs in the same season, and the importing firm is faced with a loss of business and revenue from their failure to obtain the shipment. This loss would be laid at the doors of the Department of Agriculture.

In the latter case, however, we cannot afford to be so lenient. We are faced with the responsibility of admitting diseased material, which may become established in Canadian nurseries, and from these spread to various parts of the Dominion.

Our recommendation is that not more than two per cent of disease should be permitted entry in the case of stock for propagation, and not more than five per cent in the case of bulbs for bedding and forcing. In addition the consignee should be notified of the presence of any disease in the shipment and instructions be sent covering the recognition and the removal or treatment of the diseased specimens.

The inspector's statement could be used by the consignee in lodging a complaint with the shipper, not only for the purposes of compensation, but also for education, so that the growers and shippers would take greater care in the choice of material for shipment to Canada.

EARLY BLIGHT OF THE POTATO IN LOWER QUEBEC

Moise J. Gagnon

Before approaching my subject I should like to express the pleasure with which I accepted this invitation to read a paper at the annual meeting of the Quebec Society for the Protection of Plants. For several years I have taken a particular interest in the activities of this society and I am now proud to consider myself one of those who are working actively for the better protection of plants in this province.

For three years I have been actively engaged in potato-culture in Lower

Quebec and have been in a position to estimate the damage, often quite serious which is caused annually by Early Blight of potatoes.

In consequence I have thought it as well to make a special study of this disease and it is the summarized result of three years of labour, study, research and personal observation that I wish to communicate to you today in as brief a manner as possible.

The potato

Historical.

As most people know, the potato (Solanum tuberosum) is a native of South America. It was probably brought into Europe from Peru or Chile in 1533. It is said to have been first introduced to America in 1719 by a party of Irish Presbyterians established at Londonderry, New Hampshire.

As for the Province of Quebec we know that the potato was known here before 1758. It is even said, on the authority of M. Pierre Georges Roy, archivist that the potato was known to the Indians at the time of Champlain's discovery of the Almouchiqui coast in 1605.

Economic importance.

The potato is one of the most widely cultivated of agricultural plants. On making a careful examination of the world statistics of agricultural production, we are surprised to find that its production exceeds that of oats by a million bushels. It is interesting to notice that oats takes the second place and wheat the third.

Turning to the Province of Quebec in 1922 we produced twenty-eight million bushels of potatoes values at $18,342,000.00. One may say without exaggeration that two-thirds of this production came from the lower part of the province. These figures suffice to show the importance of such an industry as potato-growing and the interest that it should have for us.

Varietal susceptibility.

There is a marked difference between the susceptibility of varieties. There is even a very noticeable difference between each hill of the same variety. A plant may be killed by early blight while a neighbouring hill of the same variety and under absolutely identical conditions remains healthy.

The disease

Name. This disease is commonly known in French as "*brûlure hâtive.*" In English it is called Early Blight of Potatoes.

History and geographical distribution. Early blight was not at first recognized as a separate disease. Tip-burn, arsenical burning and certain necroses due to insects were confused under the same name. Professor L. R. Jones and his assistant J. Grout, in 1896, for the first time established the difference between early blights and these false blights and described the symptoms peculiar to each.

It is interesting to note that Professor L. R. Jones was the first investigator seriously to study this disease in America and that not a great deal has been added to our knowledge of it since that work.

Galloway, in 1891, was the first to establish the economic importance of the disease. Previously, in 1885, he had collected it on potato leaves. Since that time the disease has been continuously spreading and now it is distributed throughout Canada and in fact the entire world, wherever the potato is grown for consumption.

Economic Importance. It is almost impossible to estimate the losses caused annually by Early Blight, because it is almost always found associated with other diseases. Nevertheless it has already been established that the annual loss frequently amounts to 10 to 25% of the crop. In Lower Quebec the damage frequently exceeds that cause by Late Blight.

Symptoms. For a long time it was believed that this disease only affected the leaves. Now, it has been proved experimentally that the tubers may also be attacked.

The first signs of the disease appear on the oldest and lowest leaves about the time of tuber-formation, that is to say shortly before flowering. They are at first characterised by small isolated yellowish spots, which are, in shape either round or oval. Frequently these spots occur where damage would have inevitably caused a necrosis; it is possible to find them anywhere on the foliage, unlike late blight which is almost always found on the edges of leaves.

As the season advances the spots slowly enlarge and, their spread being limited by the small nerves, become more and more angular in outline. Often several spots coalesce to form one large dark brown spot. Since the development of the disease is periodical, a series of concentric circles are formed which are quite characteristic in appearance.

Early Blight does not confine itself to the lower leaves, but may spread from them to the whole plant and, if conditions of temperature are favourable the spots become so numerous as to coalesce, the plant becoming exhausted and dying in a short time. The disease continues to develop even after the death of the plant.

Etiology.

Early Blight of Potatoes is caused by an Adelomycete known as *Alternaria Solani* (Ellis and Martin) Jones and Grout. Mycologists have always been divided on the nomenclature of the fungus causing Early Blight of the potato. It has been agreed that it belongs to the Adelomycetes but there is a difference of opinion as to the genus in which it should be placed. Some placing it in Macrosporium as *Macrosporium Solani E.* and M., *Macrosporium Cookei* Saccardo Cook. Others consider that it should belong to the genus Alternaria as: *Alternaria Solani* (Ellis and Martin) Jones and Grout. Eriksson in his treatise on fungous diseases attacking plants, attributes Early Blight to the fungus *Sporodesmium Solani* var. *varians* Vanha.

So far as I can judge there is a tendency among American investigators to adopt *Alternaria Solani* as the correct name for the parasite causing Early Blight of Potato.

Pathogenicity.

Chester and Galloway by a series of inoculations of potatoes established the pathogenicity of the fungus; spots appeared in from 8–10 days inoculation with the pathogen. In 1896 Jones, using pure cultures, confirmed the work of the previous investigators. He observed the characteristic spots on the third day after inoculating healthy leaves with Early Blight. Later, Dr. Rands proved by experiment that Alternaria Solani is pathogenic on the potato and some 15 other species of the family Solanaceae.

Development of the fungus. The time at which the disease appears each year appears to depend on the date of planting and on the development of the crop, the latter being influenced by soil and climatic conditions. The disease usually appears after the plant has passed its period of greatest vigour, that is to say, for the lower part of the province sometime during the months of August and September.

Inoculation. It is generally believed that the primary infections caused by spores which have hibernated in the soil or on debris from previous crops. These spores are supposed to infect the lower leaves which are in immediate contact with the soil, thus initiating the disease. On the other hand it has recently been shown that *A. Solani* (E. and M.) Jones and Grout attacks not only potato-stems, but may also cause a tuber rot accordingly. May this not provide another method of infection?

Furthermore does not Professor George Masse confirm our hypothesis in his "Diseases of Cultivated Plants and Trees" when he says.

"When a potato plant is badly infected, the mycelium passes from the haulm into the underground branches and young tubers... A tuber used for "seed" perpetrates disease, which in turn again infects the young tubers. This is exactly similar to what takes place in the case of *Phytophthera infestans*".

Incubations: In the greenhouse the incubation period is from twenty-eight to fifty hours according to the humidity. In the field, when showers are frequent enough to provide the necessary humidity, small spots may be noticeable within forty eight to seventy two hours of inoculation. The speed with which spores germinate varies considerably with the temperature. At twenty eight to thirty degrees centigrade, the optimum temperature, they germinate in less than 35 minutes.

Infection: According to Professor L. R. Jones (1896) penetration may occur readily by the stomata or through the cuticle. Under favorable conditions young leaves may be infected as readily as old ones, but the growth of the spots is decidedly slower on the former than on the latter.

The mycelium of *Alternaria Solani* is brown to olivaceous-green in colour.

The conidiophores grow in tufts through the stomata or from infected cells The conidia are oblong or shaped like snowshoes, they measure 145–370 micra by 16–18 micra; they are brown in colour. They terminate in a long hyaline beak half the lengh of the spore itself. The conidia are multicellular by five to ten transverse and some few longtitudinal septa.

Saprogenisis. The infected portion of the leaf soon dies and the fungus continues to grow. It is usually at this time that spore production begins. Although spores appear simultaneously on both sides of the leaf, they are always more abundant on the lower surface.

Second Generation: The saprophytic stage is approximately the same as the first generation. The pathogenic stage only differs in the source of inoculum which instead of being provided in debris as in the first generation arises from previously infected plants. Spores are carried from diseases to healthy plants by wind and insects. During the second generation, the infection occurs more often on the lower leaves than it does in the first.

Ecology

Early Blight is a disease of hot seasons. It causes its maximum damage in periods of high temperature and abundant moisture when the plants are some what weakened.

Control

The following measures are suggested for the control of Early Blight of potatoes:—

1. Tuber Disinfection. Since it is now generally admitted that the tubers provide a source of infection, it is wise to soak seed pieces in a disinfecting dip either of Formalin or Mercuric Chloride. A good precaution would be to use seed from a field which was not infected in the previous year.

2. The destruction of all weeds (chiefly Solanaceous) which may be parasitized by the Early Blight Organism.

3. A three to five year rotation sufficient to allow the debris from the previous crop to rot and become harmless.

4. Spraying with Bordeaux Mixture as recommended for Late Blight, Macrosporium Alternaria Solani being rather difficult to control an attempt should be made to cover all parts of the leaves and in particular the young shoots.

5. Immunity. The use of immune varieties would certainly be more effective than all the methods previously mentioned. It would also be the most economical method if really immune varieties existed, Unfortunately at present we only know of some resistant varieties and none of these are of any commercial importance. Accordingly there is a magnificent field of research for the investigators who can succeed in discovering or breeding a variety really immune to Early Blight and at the same time possessing the qualities demanded by the trade.

CROWN RUST OF OATS IN EASTERN CANADA

By William Popp.

(Abridgement of M. Sc. Thesis.)

Introduction.

Puccinia coronata Cda., the organism causing the crown rust or leaf rust of oats, occurs not only on the species and varieties of Avena but on a large number of grasses as well. The fungus is, further, heteroecious; the aecial stage is found o various species of Rhamnus commonly known as Buckthorn. But the role played by the aecial host in general epidemics of this rust is not at all clear as yet. Certain it is, however, that fields in close proximity to Buckthorn are usually more highly infected.

Since the chief grain crop grown in Eastern Canada is oats, the importance of controlling diseases as affecting that crop is obvious. That crown rust is one of the most serious limiting factors in reducing the yields is quite evident from a perusal of the summary of the "Plant Disease Survey" of Canada extending over a period of five years, from 1920 to 1924. This summary states that "in Ontario and Quebec Crown Rust caused greater losses than stem Rust, being severe on late oats. In the Maritime provinces it was of general occurrence but not markedly injurious". While no actual data are available regarding the losses due to a given epidemic yet one can safely say that it would almost be on a par with the damage done by wheat stem rust of wheat and that a loss of from 5 to 10 per cent would be a fair average.

If the generally accepted hypothesis with regard to the spread of a general epidemic or Stem Rust in Canada may also be applied to Crown Rust, then we may also assume that in the case of Crown Rust the spores are wind-blown from the south during the summer months and that they then infect the oats when conditions are favorable.

The only hope of combating this serious menace, then, aside from removing all traces of Buckthorn, lies in the production of resistant varieties of oats. That resistant varieties can be secured would seem evident from the results obtained by Biffen (6, 7) in England, who succeeded in developing a variety which was not only highly resistant to *Puccinia glumarum* Schw., but which was also commercially desirable. Garber (17, 18) too, has produced Victory-White Russian hybrids which were resistant to Stem Rust at least in Minnesota. As these hybrid strains possess the desirable characters of Victory with the Rust resistance of White Russian the future success of plant breeding as a means of solving the problem is practically assured.

Preliminary to the breeding of oats for resistance to Crown Rust, a knowledge of the varieties or strains of oats that already possess a degree of resistance is fundamentally necessary. Not only that but a determination of the physiological forms of the rust will be necessary before the value of resistant varieties may be definitely established, for it is now a well-established

fact that a variety resistant in one locality may be quite susceptible in another. This seeming anomaly was explained by Stakman and his co-workers (52,53, 54, 55, 56) by their discovery of several physiological forms of Puccinia graminis tritici, and that a variety resistant to one form may be quite susceptible to another.

With the above facts in mind hen, the present investigation limits itself to two phases of the problem only namely the testing of oats for varietal resistance and the discovery of physiological races of Crown Rust.

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Historical Summary

In summarizing the achievements of the previous investigators an attempt will be made to review only that which is directly concerned with the object of the present studies, namely, resistance of oat varieties to Crown Rust and physiological host specialization of the pathogene. Reference to results obtained in other phases of the problem will be made wherever desirable in the discussion under the heading of Experimental Materials and Methods" and that of "Experimental Results".

Varietal resistance.

Numerous instances of the production of disease-resistant crops may be noted in this and other countries, but comparatively little work has been done on the problem of resistance of oat varieties to Crown Rust. The use of resistant varieties, however, appears to be the most hopeful method of combating the fungus.

Among the earliest observations on the variation in the susceptibility of oat varieties to rust are those of Eriksson and Henning (15) in Sweden. These investigators state that it was impossible to observe any definite difference in the susceptibility of oat varieties. They considered it an open question whether the difference observed actually represented constant, inherent resistance or was dependent on soil conditions, proximity to other rust plants and other factors of environment.

Sower (49) published figures on the rust resistance of oat varieties grown at Cedara, South Africa, stating that both Crown and Stem Rust occur, though it is quite apparent from his data that only Crown Rust was present It is note worthy that three varieties belonging to the red oat group (Avena sterilis) were found to be most resistant. He also points out a relation between anatomical differences of the group and their relation to rust resistance and seems to consider these differences as being ultimately connected with causes of resistance and susceptibility. Lamont (24), Peacock (40) and McConnell (27) likewise refer to the rust resistance of certain representatives of the red oat group, though they fail to specify whether the resistance is to Stem Rust or Crown Rust.

Litwinow (22) made a study of rust resistance of oat varieties of Russia, using 50 pure lines belonging to several species and varieties. He found that all of them with the exception of the latest maturing were finally very heavily infected with Crown Rust.

Vavilov (58, 59) has reported extensive observations as to susceptibility and resistance of oat varieties to *Puccinia coronata f. avenae*. In his studies he has used three hundred and fifty pure lines belonging to twenty-four variety based on Kornicke's classifications. These varieties were distributed among eight species Avena.

Most of these pure lines were highly susceptible to Crown Rust. This was especially true of the varieties *Avena diffusa* (*A. sativa*) and *A. orientalis*, notably the white and yellow seeded sorts. The wild form of cultivated oats, viz, *A. fatua A. ludoviciana* and *A. sterilis* also proved hightly susceptible.

The most resistance forms belonged to the varieties *A. diffusa* (*A. Lativa*) with brown and gray seeds. *A.strigosa*, *A. brevis* and *A. nudavar. biaristata* also proved fairly resistant. In all twenty-four pure lines possessed considerable resistante to Crown Rust.

Vavilov's work consisted of field observations during the years of 1911 and 1912. His most susceptible varieties were characterized by the appearance of uredinia on both lower and upper leaf surfaces and, later, by telia. His resistant forms, on the other hand, had a few uredinia on the lower leaf surfaces only, accompanied by more or less flecking on the leaves; no telia appeared.

In this connection Jakushkina and Vavilov (21) studied the size, number and distribution of stomata in both resistant and susceptible varieties of oats, but found that there was little or no correlation between variation in these structures and the physiological character of rust resistance inherent in the variety.

Probably one of the earliest American records of rust resistance in oats was that of Speer (48) who reported the results of his observations on the occurrence of rust on the oat varieties growing in the Iowa Agricultural Experiment Station plots. Though no mention is made of the species of rust concerned, he states that the oats rusted so badly that they were nearly worthless with

the exception of Improved American, Everett (a side oat), Lackawanna and Giant Yellow French (also a side oat). Observations on the resistance or susceptibility of oat varieties to rust have since been made by Pammel (39), Plumb (38), Carleton (10), Bolley (4, 5, 9), Shepherd and Ten Eyck (47) and McWethy (29).

Norton (36) published definite experimental results on oat resistance and distinguished clearly between Crown and Stem Rust. He found that "The Avena sterilis forms are nearly all free from Crown Rust".

Burnett (8) found that the amount of leaf rust infection on Red Rustproof (Red Texas) was much less than on other varieties.

Reed (42) tested 46 varieties and strains of oats, under greenhouse conditions, only one of which seemed to possess any degree of resistance to Crown Rust. His field observations coincide with those made in his greenhouse experiments. The same author (41) in a later report states that in the field one lot of *A. barbata*, two of *A brevis*, three of *A. fatua*, one of *A. ludoviciana*, three of *A. nuda*, twenty-two of *A. sativa*, nine of *A. sativa orientalis*, seven of *A. sterilis*, and one of A. *strigosa* were studied. One lot of each, *A. brevis*, *A. ludoviciana*, *A. trisperma*, and *A. sativa* showed some evidence of resistance.

In addition to the tests with varieties of Avena similar experiments were made with *Arrhenatherum avenaceum*, *Holcus lanathus*, *Festuca elatior*, *Lolium Italicum*, and *Lolium perenne* as hosts. Although these grasses are also hosts for the rust *Puccinia coronata* Cda., no infection was obtained by using urediniospores from oats. This tends to confirm the existence of physiological races of this rust.

Parker (37) has also studies the behaviour of oat varieties to Puccinia coronata under greenhouse experimental conditions. He inoculated his plants at two stages of development in the seedling stage and at the time when the plants were ready to head out.

In the one hundred and twenty-two varieties or strains used eight proved entirely susceptible in both stages of development. A considerable number of the strains showed more or less resistance to Crown Rust. Nearly all of these belonged to the *Avena sterilis* group. The resistance further, was more marked in the later stage of growth than in the seedling stage. As evidence of resistance such points as longer incubation period, the small size of uredinia and the formation of flecks on the leaves were taken. Parker also emphasizes the fact that telia did not appear following abundant production or urediniospores. He records the appearance of teliospores on leaves of seedlings on which urediniospores were not produced normally and which gave other evidences of resistance. It may be noted here that the appearance or non-appearance of telia is given a different significance by Parker and Vavilov.

Durrell and Parker (12) tested two hundred lots of oats. They observed that the greater susceptibility of seedlings is suggested not only by an average of 18 per cent more rust obtained on them, but also by the shorter incubation

period of the rust. The incubation period on seedlings is two days shorter than on half grown or older plants.

Avena barbata was the most resistant oat. Other varieties were Appler, Burt, Early Ripe, Golden Rustproof and Ruakura and the species *A sativa trisperma* and *A. brevis*.

Durrell and Parker in 1920 also reported the percentage of Crown and Stem Rust appearing on hybrids in the greenhouse and rust nursery in 1917 and 1918. These hybrids were designated as fellows: Early Ripe x Black Mesdag, Early Champion x Early Ripe, Early Ripe x Sixty-Day and Swedish Selects x Early Ripe. While the amount of varied rust considerably none of the hybrid were constantly resistant.

The results of the varietal experiments conducted in the greenhouse by Durrell and Parker indicate that the varieties of the red oat group, Avena sterilis, show more resistance to Crown Rust than those of the common oat group, *A. sativa*. The most resistant varieties in the species *A. sterilis* were found to be Appler and Red Rustproof. The varieties Ruakura, *A. barbata* were resistant to both rusts.

Evans (16) has tested the rust resistance of oat varieties in the greenhouse and concludes that the Indian varieties are far more susceptible to Crown Rust than to Stem Rust.

The Report of the Dominion Botanist (19) for 1925 showed that in field tests some of the varieties showing more or less resistance to Crown Rustwere follows: *Ave. nuda*, *A. brevis*, Red Rustproof, *A. strigosa*, *A. sterilis nigra*, Burt, Early Dakota, Green Russian, Canadian, C. I. 602, Irish Victor, June, Swedish Select, Lincoln, C. I. 749, Garton 748, Garton 784, Black Tartarian, Sparrowbill, Tartan King, Green Mountain, Old Island Black and Banner. The report states, however, that the above experiments were carried out during an unfavorable season for the development of Crown Rust.

Physiological specialisation.

The phenomenon of physiological specialization in rusts has lately become not only of scientific interest but more especially of practical importance because it may establish a basis for securing rust resistance.

In reviewing the literature relative to physiological specialization, one is impressed with the relatively small amount of investigation carried on in the study of special forms of Crown Rust. To gain a comprehensive idea of the extent of this work, one must of necessity summarize in part the investigations of a similar carried out with other parasites.

But since the whole field of physiological specialization has been so ably reviewed by Reed (43) and again in the case of specialization in the general rusts by Stakman (46) it was thought advisable only to review tho sepapers which are strictly relevant to the aim of the present problem.

In 1922 Stakman and Levine (57) reported a total of thirty-seven races of *Puccinia graminis tritici*. Miss Newton (35) in 1922 made a survey of wheat stem rust in Canada and found fourteen of the thirty-seven physiological races known to exist in the United States.

To test the question of the possible temporary character or mutability of these races, Leach (25) and Stakman Levine and (52) studied the behaviour of one of them, *Puccinia graminis tritici compacti*, and found it to be as constant parasitically as the forms originally described by Eriksson (13).

Recently Maine and Jackson (28) have shown that *Puccinia triticina* Erik. consits of at least two forms. Still later the same authors (30) demonstrated that leaf rust of wheat, *Puccinia triticina*, consists of at least twelve physiological forms distinguished by the manner in which they infect eleven selected differential strains of wheat.

Various workers have reported physiological specialization in the sunflower rust, *Puccinia helianthi* Schw., but results had not been conclusive until 1922, when Bailey (3) was able to demonstrate definitely three distinct types of infection on *Helianthus annuus*, supplying final proof of the existence of physiological forms of this fungus.

Stakman, Levine and Bailey (44) in 1923 working with stem rust of oats reported five physiological forms of stem rust to occur. These were identified by their action on Victory (C. I. 1145), White Russian (C. I. 1614) and Monarch Selection.

Melhus, Dietz and Willey (31) in 1922 inoculated a wide range of grass hosts with Crown Rust from cultivated oats and wild grasses and distinguished four physiological races.

It is also evident from the results of Hoerner's experiments (20) that there are several physiological forms of Crown Rust on varieties of oats. Four distinct physiological forms of rust could be distinguished on the basis of their action on Ruakura Rustproof (Iowa 73) and Green Russian (Iowa 96) The action of these forms on these selections may be summarized as follows:

Form 1 infects both Iowa 73 and Iowa 96 normally.
Form 2 " " varieties weakly.
" 3 " Iowa 73 weakly but infects Iowa 96 normally.
" 4 " " 73 normally but infects Iowa 96 weakly.

W. L. Gordon, M. Sc., formerly of Macdonald College, in his unpublished report of 1924-25 reported the presence of at least three strains of Crown Rust in Eastern Canada. The differential hosts held were Sterilis Selection and White Russian (Minn. 539). The reactions to the three cultures (not pure line cultures) were as follows:

Culture 7 infects Sterilis Selection normally and White Russian weakly.
" 10 " " " weakly " " " normally.
" 8 " " " weakly " " " weakly

Experimental materials and methods

Collection of Inoculum.

On account of our knowledge concerning the existence of physiological forms of rust and their distribution over various geographical areas, it seemed at first necessary to make a survey of representative localities throughout Eastern Canada or the provinces of Ontario, Quebec, Nova Scotia, Prince Edward Island and New Brunswick. With this in view Gordon, by his own efforts and the co-operation of various persons mentioned in Table 1, was able to secure in 1924 eleven cultures of Puccinia coronata Corda. He commenced work on the problem in August, 1924. In the summer of 1925 eleven more cultures were collected. As shown in Table 1, there are now twenty-two cultures with which the present investigation concerns itself.

The number of collections of Crown Rust from each of the provinces is represented as follows:

Ontario	5.
Quebec	8.
Prince Edward Island	5.
New Brunswick	3.
Nova Scotia..	1.

TABLE I

Cultures of Puccina coronata Coda.

Culture Number	*Place Collected*	*Date*	*Host.*	*Collected by*
1	Fredericton, N. B.	Aug. 29/24	Avena Spp.	R. C. Parent.
14	New Mills, N. B.	Aug. 12/25	" "	A. R. Graham.
17	Fredericton, N. B.	Sept. 2/25	" "	R. C. Parent.
2	Kapuskasing, Ont.	Aug. 23/24	" "	W. L. Gordon.
4	Falkenburg, Ont.	Aug. 5-25	" "	"
7	O. A. C., Guelph, Ont.	Oct. 3/24	" "	Prof. J. E. Howitt.
10	Devlin, Ont.	Aug. 31/24	" "	J. Tucker.
11	Manitoulin Island, Ont.	Aug. 11/24	" "	"
3	Lachute, P. Q.	Sept. 1/24	" "	W. L. Gordon.
5	Hemmingford, P. Q.	Sept. 6/24	" "	G. H. Hammond.
6	Ste. Anne de Bellevue, P. Q.	Sept. 13/24	" "	W. L. Gordon.
12	Hemmingford, P. Q.	July 23/25	" "	G. H. Hammond.
13	Lachute, P. Q.	Aug. 5/25	" "	W. L. Gordon.
19	Ste. Anne de Bellevue, P. Q.	Aug. 7/25	Algerian	"
20	Macdonald College	June 4/25	Buckthorn	"
22	Lachute, P. Q.	Sept. 23/25	Avena Spp.	"
8	Charlottetown, P. E. I.	Sept. 23/24	" "	R. H. Smith.
15	St. Peters, King's Co., P. E. I.	Aug. 28/25	" "	K. A. Harrison.
16	Cardigan, P. E. I.	Aug. 31/25	" "	"
18	Charlottetown, P. E. I.	Sept. 5/25	" "	"
21	St. Peters, P. E. I.	Aug. 8/25	" "	"
9	Gaspareaux, N. S.	Sept. 18/24	" "	H. S. Cunningham.

Inoculation.

For maintaining a stock supply of the various rust cultures, victory oats were always planted and inoculated at regular intervals for this variety is susceptible to all known forms of Crown Rust. Usually from eight to ten plants were grown in 3½ or 4-inch pots. Previous to inoculation all plants were

kept in an adjoining greenhouse in which no rust cultures were present. But at the time of inoculation these pots containing the seedlings were carried to the respective rust cages (as shown in Plate 2) in another section of the greenhouse and inoculated there.

The oat seedlings of any given variety were inoculated usually and as nearly as possible when three or four inches high. The methods adopted were those employed by Melhus (32) and Melchers (33). The waxy coating, which prevented water from adhering readily on the leaves, was removed first by gently drawing the leaves between wet fingers. The plants were then wethed by atomizing with a DeVilbiss atomizer. Spores were removed, from the rusted plants kept as stock culture, with a straight-edged scalpel and spread on the wetted leaves. The plants after another spraying with distilled water were finally covered with a bell-jar which served the purpose of an incubation chamber. After a period of forty-eight hours the bell-jars were removed.

Every precaution was taken to prevent contamination. For instance the pots inoculated with a given culture was enclosed in compartments as shown in Plate 2; the scalpel was flamed before and after each inoculation; and the hands were washed in water and finally in alcohol.

It will be noted that the twenty-two compartments containing the several cultures are curtained off with heavy factory cotton and that they may be opened at the sides by raising a corner or a side curtain. The tops of the cages were protected during the summer months from outside contamination by cotton material. For as shown by Stakman *et al* (45) the urediniospores are at all times present in the air during the summer season even at an altitude of 10,000 feet. After infection had taken place and the bell-jars had been removed, the environmental conditions were such that danger from outside infection was comparatively negligible.

During the fall and spring months notes were usually taken at the end of about ten or twelve days after inoculation, but in the winter months during unfavorable environmental conditions the periods was extended to about seventeen or twenty one days from the time of inoculation.

Varieties tested.

The first essential in the present studies was to determine oat varieties which showed marked resistance to one or more of the collections. In this way, after running all of them through the various cultures once, the resistant varieties thus ascertained could again be tested and varieties which showed constant reaction could be chosen as differential hosts for the determination of physiological strains.

Accordingly ninety varieties of oats were obtained in the fall of 1925 from the seed plots of Macdonald College. Table 2 shows these oat varieties to be classified and apportioned under the following species:

Avena Sterilis. Avena Nuda. Avena Sativa. Avena Orientalis .

The several varieties or strains were tested for susceptibility to Crown Rust usually in parallel. For instance, as an example for the twenty-two cultures of rust twenty-two pots of Victory and twenty-two pots of Green Russian seedlings would be sown and inoculated at the same time. By this means an accurate method of comparison be had between the most susceptible variety and one which might be less so. Environmental factors play an important part in rust infection work.

Types of reaction.

In order to establish a uniform method of recording data in the study of the different kinds of host reaction, the classes of infection are graded into five classes as shown in Plate 3. This is the method adopted by Stakman and Levine (57) *et al*, and is presented herewith as follows:

Classes of Host reaction.	Types of Rust infection.
0. Highly Resistant.	No uredinia formed ; small flecks, chlorotic or necrotic areas more or less prevalent.
1. Very Resistant.	Uredinia few, small always in small necrotic spots. Also more or less necrotic areas produced without development of uredinia.
2. Moderately Resistant.	Uredinia fairly abundant, of moderate size, always in necrotic or very chlorotic spots. Necrotic spots seldom without uredinia.
3. Moderately Susceptible.	Uredinia fairly abundant, of moderate size. No necrosis produced, but sometimes slight chlorosis immediately surrounding the uredinia.
4. Very Susceptible.	Uredinia abundant, large. No necrosis or chlorosis immediately surrounding the uredinia. Infected areas sometimes sourrunded in each case by a chlorotic ring.

Other characteristics such as chlorosis, necrotic areas, and telia were made note of in our private notes by the letters C. N. and T. respectively. The variable reactions of mixtures were known by the symbol X; and again where a given reaction was midway between two different classes of infection a plus or minus sign, according to whether the degree of infection was lighter or heavier, was annotated.

Pure lines of Crown Rust.

Quite late in the course of the present studies it became apparent to the writer that some of the cultures were mixed. As a matter of fact the experience of other investigators, namely Mains and Jackson (30) Miss Newton (35) and Stakman and Levine (57 practically corroborates this statement, for their results show that field collections are usually mixtures of strains or races. Immediately therefore after this fact became known, the writer determined

to isolate single spores from these cultures and thus establish so-called pure line cultures as described by Mains (34). A representative sample of spores was shaken from a given culture into a petri dish which was then placed under the highest powers of a binocular microscope. A single spore having been located the same was removed by the tip of a finely drawn out glass rod, previously moistened with distilled water. The spore was then inoculated on Victory oats. About ten spores were so placed on separate leaves or seedlings in the same pot and from the same culture; and the same were then covered with bell-jars as described above. To prevent contamination the bell-jars were kept over the pots permanently. When the first signs of infection became apparent all plants except one were discarded from a pot. The single uredinia thus obtained was allowed to mature and the spores were immediately used to inoculate Victory seedlings to be used for stock culture purposes.

One of the interesting facts revealed in the present study was the difference in the amount of rust infection shown by a number of varieties between their greenhouse tests and infection in the field. For instance the summary of the plant disease survey from the rust nurseries of Prince Edward Island states that under field conditions White Tartar escapes Crown Rust infection entirely while slight infection occurs on Iowa, Richland, Burt and Green Mountain. This seems to conflict with the greenhouse tests made here, for Richland proved quite susceptible while White Tartar had a variable type of infection such as would indicate a mixture of strains. This was made evident by the presence of distinct necrotic areas and normally developed uredinia on the same leaf blade. The fact, however, that White Tartar exhibits a high degree of hypersensitive but variable reaction may be of significance. In this connection it has repeatedly been observed by other investigators that the rust will infect a given variety more severly under greenhouse than under field conditions. Moreover a difference also exists between infection produced on mature plants and that made on seedlings. Seedlings in the greenhouse invariably show a more vigorous infection than the more mature plants infected in the field. Obviously then it would seem that the resistance of White Tartar, though slight and various in greenhouse tests, would be more pronounced on plants reaching maturity in the field.

A rust report from Fredericton, N. B. points with particular emphasis to the extreme susceptibility of the Alaska oat to Crown Rust in that district. This agrees with the results of our greenhouse tests at Macdonald College for very heavy infection resulted from the inoculations of each of the 22 cultures on that variety.

Of the 90 varieties of oats tested, it will be noted that 15 have indications of possessing more or less immunity to one or more of the cultures. The *Avena nuda* group does not show any resistance. All of the varieties in the *Avena sterilis* class are in varying degrees resistant to Crown Rust. Unfortunately, however, these same varieties are quite susceptible to Stem Rust. In the classes of *Avena sativa* and *Avena orientalis*, the following varieties exhibit hypersens-

itiveness or resistance to Crown Rust infection; Green Russian (Iowa 96), Green Mountain, White Tartar, White Russian (C. I. 1614), White Russian (Minn. 539) and C. I. 620. White Tartar, White Russian and Green Mountain are identical varieties that are kept separate here on account of being special selections.

In all cases of extreme hypersensitiveness or resistance to the rust fungus, the plants showed marked killing of the infected tissues; the extreme sensitivity of the host to the fungus causing a rapid development of necrosis and the consequent of the spread of the parasite.

Burt (A. sterilis) While showing extreme resistance in some seedlings is evidently a very variable oat (11), for its reactions were never constant in repeated trials. This was also evident by the fact that seedlings in the same pot that had been inoculated with the same culture proved differential in their reaction (Plate 4).

The variety King (*A. sterilis*) gives a variable reaction on the same leaf and it is on that account exceedingly difficult to classify an infection. But the variations thus shown are designated by the letter x as illustrated in Plate 3. This type of reaction no doubt conforms to the findlings of Stakman and Levine (57).

Algerian (*A. sterilis*) on the other hand corresponds to Burt in its variability. The reaction of seedlings in the same pot are often quite different. This variety, however, is not as resistant as Burt.

Early Ripe 213 is also a very variable oat for its reactions correspond to both that of Burt and Algerian.

Avena sterilis Selection is a very resistant variety. In preliminary tests, however, cultures 7, 12 and 16 infected it quite normally. These cultures originate from the Ontario Agricultural College, Guelph; Hemmingford, Quebec; and Cardigan, Prince Edward Island respectively, as shown in Plate I. Accoringly there would seem to be of no apparent correlation between the degree of infection and the origin of the cultures. In other words these cultures, though causing the same infection, originate from widely separated localities.

The variety King is heterogenous in its reaction to the culture. The infection on a leaf or between different leaves (plants) in the same pot may vary from type to type 4 infection.

Ruakura Rustproof, a strain of *Avena sterilis*, is quite if not more resistant to Crown Rust than is Sterilis Selection. The same variety or another selection of it was used by Hoerner (20) as a differential host in determining the presence of a number of races of the rust.

Oklahoma 606 (*A. sativa*) can only be said to be moderately resistant as the uredinia produced are not very large or abundant. This is no doubt due to the less vigorous and spindly character of the growth of the host which also reacts on the growth of the rust. Definite signs of resistance are present in most cases.

Among strains of *Avena sativa* the majority are very susceptible. This is, of course, unfortunate when one considers their economic value. C. I. 620 is a moderately resistant variety. The most highly resistant strain tested was Green Russian (Iowa 96). It was used by Hoerner as the other differential host in his determination of physiological strains of Crown Rust.

Old Island Black was also fairly resistant. It differs from Green Russian (Iowa 96) in that the former is infected heterogenously by nearly all of the cultures, while in Green Russian (Iowa 96) the degree of infection can be determined quite definitely.

In analyzing the *Avena orientalis* oat strains we may also find some very resistant sorts. White Russian (Minn. 539), Green Mountain, and White Tartar are very pronounced, while White Russian (C. I. 1614) is only moderately resistant in some cases and quite susceptible to other cultures.

The variable infection obtained upon White Tartar seedlings and to a lesser degree upon White Russian (C. I. 1614), has been mentioned above; and the reaction for the former is illustrated in Plate 3 by the symbol x.

In concluding the remarks regarding the results of general infection work, it may be said here that the reactions of some of the hosts or varieties of oats would indicate a mixture of strains or races of rust, aside from the natural tendency inherent in some of the varieties as Old Island Black, White Tartar, White Russian (C. I. 1614) and King to react heterogenously.

General characteristics of some of the resistant varieties.

According to Coffman *et al* (11) the variety known as Burt is a selection made from Red Rustproof. It is one of the principal representatives of the red-oat varieties. Burt, May, Early Ripe and June are probably different names for the same variety. It is widely adapted to different regions ewing to its drought resistance and earliness; and it is grown quite extensively in the United States. According to Zavitz (61), it was the earliest among 260 varieties grown at the Ontario Agricultural College and apparently was immune to attacks of smut, but it was not considered to be of much agricultural value for the province of Ontario.

Strains of Early Ripe (Burt) are being tested by the Agronomy Department Macdonald College, Quebec. The selections will probably be of value in breeding for rust resistance.

(Red) Algerian was obtained from New Zealand where it is grown extensively in South Island. It appears to be the most resistant of any oat variety grown there. Further, according to Leppan and Posnan (23) in South Africa, it is popular on account of its hardiness, resistance and yielding qualities. It grows also on soils too poor for Boer oats. Special characteristics are a spreading panicle and a yellowish brown grain.

Green Russian (Iowa 96) is a strain of Green Russian recently obtained

from Dr. S. M. Dietz, Assistant Pathologist, Experiment Station, Iowa. It is resistant to some forms of Stem Rust as well.

Oklahoma 606 appears to be a strain having *Avena sativa* characteristics.

Differential host reactions (with pure line cultures.)

In Table 1 are listed the following varieties: Sterilis Selection, White Russian (Minn, 539), Green Russian (Iowa 96) and Ruakura Rustproof. It will be noted that there is a similarity of infection between White Russian (Minn. 539), Green Russian (Iowa 96) Sterilis Selection, however, proves to be a differential host when compared with any one or both of the former varieties. Ruakura Rustproof, on the other hand, did not show a constant reaction in the tests made and therefore is not a suitable differential host for the determination of physiological strains. On further trials, however, it may prove otherwise than here shown, for the first test made was with inoculum from a single uredinium; and it is therefore quite possible that, as the spores were rather limited and perhaps immature, no infection took place. Still another explanation may be that this variety, obtained from Manitoba Agricultural College, is not quite pure.

The results of infection of these single spore isolation cultures seem to confirm the belief of a mixture of strains in some of the original culture material for the latter were never constant in most cases. The single spore cultures, however, prove consistent both in the duplicate and in the triplicate trials. Moreover in the latter case the inoculations of the same variety were not carried out at same time but at intervals of at least a week.

As stated above, Sterilis Selection, White Russian (Minn. 539)and Green Russian (Iowa 96) are differential hosts for determining the physiological races of Crown Rust present. The differential host reaction according to forms is diagramatically represented in Table 2. For convenience of distinction the forms are numbered in consecutive order. The reaction of the hosts of these forms may here be briefly stated as follows:

Form I (Cultures 1, 3, 4, 6, 9, 11, 16 and 22) infects Sterilis Selection weakly; White Russian (Minn. 539) normally and Green Russian (Iowa 96) normally.

Form 2 (Cultures 2, 5, 8, 10, 14, 18, 19 and 21) infects all three varieties weakly.

Form 3 (Cultures 7 and 13) infects Sterilis Selection normally; White Russian (Minn. 539) weakly; and Green Russian (Iowa 96) weakly.

Form 4 (Cultures 12, 17, 15 and 20) infects all varieties more or less normally.

It may be noted here that in a few odd cases as shown in Table 1, contamination may have taken place from an old stock culture kept in the same cage. This, however, refers only to an extreme variation as from complete resistance to susceptibility.

TABLE I—Single spore isolation results.

CULTURE NUMBERS.

—	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Sterilis Selection.....	0	0	0	0	0	0	(0) 4	0	0	0	0	2+	4	0	4	0	2+	0	0	4	0	0
"	0	0	0	0	0	0	2	0	0	0	0	2-	3+	0	3	0	3	0	0	3	0	0
"	0	0		0		0, 1	3						3			0, 1	3				0	
White Russ. (Minn. 539)..	3	0	3	3	(1) 0	3	0	0	3	1+ 0	3	2+	1-	2- 0	3	3	3	1+ 0	0	3	0	3
"	3	0	3	3	(1) 0	3	0	0	3	(1) 0	3	2+	0	0	3	3	3	0	0	3	0	3
"	3	0		3		3	0, 1						0			3	3				0	
Green Russ. (Iowa 96)....	4	0	4	3	0	3	0	0	4	0	4	4	(3) 0	0	4	4	3	0	0	4	0	4
"	3	0	3	3	1	3	1-	1-	3	0	3	3	0	0	1-	3	3	3	0	0	3	0	3
"	3	0		3		3	0						0			3	3				0	
Ruakura Rust-proof.....	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
"	0	1-	0	(2) 0	(1) 0	(1) 0	C	0	0	0	0, 2	1-	(2) 4	(1) 0	2	0	1, 2	0	0, 2	(3) 1	0	0
"	0	0		(1) 0		0	0						3			1	0, 1				0, 1	

TABLE II

Form Nos.	Culture Nos.	Origin of Culture	Types of infection		
			Stirilis Selection	White Russ. Minn. 539.	Green Russ. (Iowa 96)
I.	1	Fredericton, N. B	0	3	4-
	3	Lachute, Que	0	3	4-
	4	Falkenburg, Ont	0	3	3
	6	Ste. Anne de Bellevue, Que	0	3	3
	9	Gaspareaux, N. S	0	3	4-
	11	Manitoulin Island, Ont	0	3	4-
	16	Cardigan, P. E. I	0	3	4-
	22	Lachute, Que	0	3	4-
II.	2	Kapuskasing, Ont	0	0	0
	5	Hemmingford, Que	0	1-	1-
	8	Charlottetown, P. E. I	0	0	1-
	10	Devlin, Ont	0	1-	0
	14	New Mills, N. B	0	1	1-
	18	Charlottetown, P. E. I	0	1-	0
	19	Ste. Anne de Bellevue, Que	0	0	0
	21	St. Peters, P. E. I	0	0	0
III.	7	O. A. C. Guelph, Ont	3-	0	1-
	13	Lachute, Que	4-	1-	03
IV.	12	Hemmingford, Que	2	2-	4-
	17	Fredericton, N. B	3-	3	3
	15	St. Peters, P. E. I	4-	3	4-

SUMMARY

1. The Crown Rust of oats, *Puccinia coronata* Cda., consists of at least four physiological forms which are determined by the manner in which they infect 3 strains of oats.

2. Whether the above forms are similar to those found by Hoerner (20) could not be determined owing to unsatisfactory data with regard to the infection of Ruakura Rustproof. It is also doubtful whether this strain of oats is similar to that used by tha above investigator.

3. Fifteen strains of oats have been found to be more or less resistant to one more of these forms. These are Algerian (*A. sterilis*); Burt (*A. sterilis*); Early Ripe (213 M. C.), (*A. sterilis*); King (*A. sterilis*); Ruakura Rustproof (*A. sterilis*); Sterilis Selection (*A. sterilis*); C. I. 620 (*A sativa*); Green Russian (Iowa 96), (*A. sativa*); Green Russian (*A. sativa*); Old Island Black (*A.sativa*); Oklahoma 606 (*A. sativa*?); Green Mountain, (*A. s. orientalis*); White Tartar (*A. s. orientalis*); White Russian (C. I. 1614), (*A. s. orientalis*); and White Russian (Minn. 539), *A. s. orientalis*).

The differential hosts used in the determination of physiological forms were Sterilis Selection, White Russian (Minn. 539) and Green Russian (Iowa 96). The forms of rust, however, may be distinguished by the comparison of either Sterilis Selection with White Russian (Minn. 539) or Sterilis Selection with Green Russian (Iowa 96).

5. No variety has been found which has proved entirely resistant to all of these forms.

6. The cultures as found in the field are, for the most part a mixture of forms.

7. Pure lines of rust have been developed by stating each culture from single urediniospore.

8. The physiological forms are not markedly fixed or limited in their distribution.

BIBLIOGRAPHY

1. Allen, Ruth F., Resistance to Stem Rust in Kanred Wheat. Sci. 53: 575-576, 1921.
2. Anderson, H. C., Rust on Wheat Experiments and Their Object. Agr. Gaz. New South Wales 1: 1, 1890.
3. Bailey, D. L., Investigations on Puccinia helianthi Schw. (Abstract) Phytopath. 12: 44, 1922.
4. Bolley, H. L. and Pritchard, F. J., Rust Problems, Facts, observations and Theories; Possible Means of Control. N. Dak. Agr. Expt Sta. Bull. 68, 1906.
5. Bolley, H. L., Wheat Rust. Indiana Agr. Expt. Sta. Bull. 26, 1889.
6. Biffin, R. A., Studies in the Inheritance of Disease Resistance II. Jour. Agr. Sci. *4:* 421-429, 1912
7. Biffen, R. A., Studies in the Inheritance of Disease Resistance. Jour. Agr. Sci. *2:* 109–128, 1907.
8. Burnett, L. C., Some Data for Oat Growers. Bull. Ia. Agr. Expt. Sta. *128:* 89–127, 4 fig., 1 pl.
9. Bolley, H. L., A Preliminary Report upon the Relation of the Time of Seeding and Period of Development of Rusts and Smuts in Oats. Proc. 17th. Ann. Meeting Soc. Prom. Agr.
10. Carleton, M. A., Cereal Rusts of the United States; A Physiological Investigation. Bull. U. S. Dept. Agr. Div. Veg. Phy. and Path., *16:* 1–74, 1899.

11. Coffman, F. A. and Quisenberry, K. S., A Multiflorous Variation in Burt Oats. Jour. Heredity *14:* 185–192, 1923.
12. Durrell, L. W. and Parker, John H., The Comparative Resistance of Varities of Oats to Crown and Stem Rusts. Iowa Res. Bull. *62:* 56, p. 1920.
13. Eriksson, Jakob. Ueber die Specialisierung des Parasitiesms bei den Getreiderost pilzen. Ber Deutsch. Bot. Gesells. 12: 331, 1894.
15. Eriksson, Jakob and Henning, Ernst. Die Hauptresultate einen neuen Untersuchung uber die Getreiderosts. Ztschr. Pflanzenkrank. *4:* 66–73 140–142, 197–203, 257–262, 1894.
16. Evans, I. B. Pole. South African Cereal Rusts with Observations on the Problems of Breeding Rust-Resistant Wheats. Jour. Agr. Sci. *4:* 95–104, 1911.
17. Garber, R. J., A preliminary note on the Inheritance of Rust Resistance and Panicle Type of Oats. Jour Amer. Soc. Agron. *13:* 41–43, 1921.
18. Garber, R. J., Inheritance and Yield with Particular Reference to Rust Resistance and Panicle Type of Oats. Minn. Agr. Expt. Sta. Tech. Bull. *7:* 62 p., 1922
19. Gussow, H. T., Report of the Dominion Botanist, Dom. Can. Dept. Agr. p. 43, 1924.
20. Hoerner, G. R., Biologic Forms of Puccinia coronata on Oats. Phytopath. *9:* 309–314 1919.
21. Jakushkina, O. V. and Vavilow, N., Eine anatomische Untersuchung einiger Haferrosten mit Rucksicht auf die Frage uber die Beziehungen zwischen dem anatomischen Bau und den physiologischen Eigenschaftender Pflanzen. Russ. Jr. Expt. Landw. 13; 830–861. German Resume 855–861, 1912.
22. Litwinow, N. Ueber die verschiedeme widerstands-fahigkeit der Formen des Sommergetreides gegen Rost. Bull. Angen. Bot. Jahrg. *5:* 399–423, 1912.
23. Leppan, H. D. and Bosman, G. J., Field Crops in South Africa. p. 263, 1923.
24. Lamont, W. J., Relative Rust Resistance and Yield of Various Varieties of Wheat and Oats. Agr. Jr. Cape Good Hope, *37:* 243–248, 1910.
25. Leach, Julian G. The Parasitism of Puccinia graminis tritici Erikss. and Henn. and Puccinia graminis tritici-compacti. Stak. and Piem Phytopath. *9:* 59–88, 1919.
26. Levine, M. N. and Stakman, E. C. A. Third Biologic Form of Puccinia graminis on Wheat. Jour. Agr. Res. *13:* 651–654, 1918.
27. McConnell, Primrose. The Ruakura Oat. Plant selection and Breeding. Jr. Agr (Wellington) *6:* 133–136, 1913.
28. Mains, E. B., and H. S. Jackson. Strains of the Leaf-Rust Puccinia tritici in the United States (Abstract). Phytopath. *13:* 36.
29. McWethy, L. B. Some Characteristics of Oats. Mich Farmer, *5C:* 466, 1906.
30. Mains, E. B. and Jackson, H. S. Physiological Specialization in the Leaf-Rust of wheat, Puccinia triticina Erikss. Phytopath. *16:* 89–120, 1926.
31. Melhus, I. E., Dietz S. M. and Willey, F. Alternate Host and Biological Specialization of Crown Rust in America Iowa Agr. Expt. Sta. Res. Bull. *72:* 211–236, 1922.
32. Melhus, I. E. Culturing of Parasitic Fungi on the Living Host. Phytopath 2: 197–203.
33. Melchers, L. E. A Way of Obtaining an Abundance of Large Uredinia from Artificia Cultures. Phytopath. *5:* 236–237, 1915.
34. Mains, E. B. Notes on Greenhouse Culture Methods used in Rust Investigations. Ind. Acad. Sci. *33:* 241–257, 1924
35. Newton, M., Studies on Wheat Stem Rust (Puccinia graminis tritici). trans. Roy Soc. Canada *16:* (Sect. V.): 153–210, 1922.
36. Norton, J. B., Notes on Breeding Oats. Rep Amer Breeders Assoc. *2:* 280–285, 1907.
37. Parker, John H. Greenhouse Experiments on the Rust Resistance of Oat Varieties. Bull. U. S. Dept. Agr. *629*, 1918.
38. Plumb, C. S. The Geographic Distribution of Cereals in North America. Bull. U. S. Dept. Agr. Div. Biol. Survey, *11;* 24, 3 fig. 1 col. map. 1898.
39. Pammel, L. H. Experiments with Fungicides. Bull. Ia. Expt. Sta. *16:* 315-329. 3 fig. 1892.
40. Peacock, R. W. Rust in Wheat and Oats. Bathhurst Expt. Farm. Agr. Gaz. N. S. Wales, *22:* 1013–1016, 1911.
41. Reed, G. M., A Systematic and Physiological Study of Rusts. How the Station Works. Bull. Mo. Agr. Expt. Sta. *151:* 31, 1917.
42. Reed G. M., Hursh, C. R. and Brentzel, W. E. A Systematic and Physiological Study of Rusts. Work and Progress of the Agricultural Experiment Station for the Year ended June 30, 1916. Bull. Mo. Agr. Expt. Sta. *147:* 28, 1917.
43. Reed, C. M. Physiological Specialization of Parasitic Fungi. Brooklyn Bot. Gard. Memoirs *1:* 348–409, 1918.
44. Stakman, E. C., Levine, M. N. and Bailey, D. L. Biological Forms of Puccinia graminis on Varieties of Avena spp. Jour. Agr. Res. *24:* 1013–1018, 1923.
45. Stakman, E. C. et al Spores in the Upper Air. Jour Agr. Res. *24:* 599–606, 1923.

46. Stakman, E. C. A Study in Cereal Rusts; Physiological Races Minn. Agr. Expt. Sta. Bull. *138:* 1914.

47. Shepperd, J. R. and Ten Eyck, A. M. Crop Report for 1898. Bull. N. Dak. Agr. Expt. Sta. *39:* 413–438, 3 fig. 1899.

48. Speer, R. P. Our Rusted and Blighted Wheat, Oats and Barley in 1890. Bull. Ia. Agr. Expt. Sta. *1(:* 391– 400, 1890.

49. Sower, E. R. Cereals in South Africa. Cedara Memoirs on South African Agriculture 1. Pietermaritzburg 1909.

50. Stakman, E. C. and Levine, M. N. Effect of Certain Ecological Factors on the Morphology of the Urediniospores of Puccinia graminis. Jour. Agr. Res. *15:* 1919.

51. Stakman, E. C. and Hoerner, G. R. Occurrence of Puccinia graminis tritici-compacti in Southern United States. Phytopath. *8:* 141–149, 1918.

52. Stakman, E. C., and Piemeisel, F. J., and Levine M. N. Plasticity of Biologic Forms of Puccinia graminis. Jour Agr. Res. *15:* 221–250, 1918.

53. Stakman, E. C. and Piemeisel, F. J. Biologic Forms of Pucciniagraminis on Cereals and Grasses. Jour Agr. Res. *1(:* 429–495, 1917.

54. Stakman, E. C. and Piemeisel, F. J. A New Strain of Puccinia graminis. (Abstract) Phytopath. *7:* 73, 1917.

55. Stakman, E. C., Parker, John H., and Piemeisel, F. J. Can. Biologic Forms of Stemr Rust of Wheat Change Rapidly enough to Interfere with Breeding for Rust Resistance? Jour. Agr. Res. *4:* 111–123, 1918.

56. Stakman, E. C. Levine, M. N. and Leach, J. G. New Biologic Forms of Puccinia graminis Jour. Agr. Res. *1(:* 103–105, 1919.

57. Stakman, E. C. and Levine, M. N. The Determination of Biologic Forms of Puccinia graminis on Triticum spp. U. of Minn. Agr. Expt. Sta. Tech. Bull. 8, 1922.

58. Vavilov, N. I. Beitrage zur Frage uber die verschiedene Widerstandsfahigkeit der Getreide gegen parasitische Pilze Arb. Versuchssta. Pflanzenzucht. Moskover Landw. Inst. *1:* 110. Resume in German 90–108, 1913.

59. Vavilov, N. I. Der gegenwertige Stand der Frage nach ler Immunitat der Getreide gegeo Pilzkrankeiten Arb. Versuchssta. Pflanzenzucht. Moskover Landw. Inst. *1:* 113–158, 1913.

60. Vavilov, N. I. Immunity of Fungous Diseases as a Physiological Test in Genetics and Systematics, Exemplified in Cereals. Jr. Genetics *4:* 49–65, 1914.

61. Zavitz, C. A. Farm Crops. Bull. Ont. Dept. Agr. 228: 80, 1915.

A SPOTTING AND SHRINKING OF POTATOES IN STORAGE.

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This is merely a preliminary report on a disease found on our potatoes in storage in December 1925. The author makes no claim that this is entirely new, but it is merely brought up here on the ground that it is not common. A number of tubers were found that had dark, circular depressions. Not being familiar with any disease producing such spots cultures were made to ascertain the presence of a micro-organism. The result was a copious growth of mycelium and a good crop of spores resembling those of Early Blight. Further search revealed that about 0.5% of our potatoes were affected. One lot of tubers, from vines that had not been sprayed with Bordeaux Mixture, had as high as 2% infection. The increase in infection in unsprayed potatoes strengthened our belief that it might be Early Blight.

The disease on the tubers appears like dark, circular depressions from 1 to 2 centimeters in diameter, (Fig. 1.). The number of these spots may very from one to several on a tuber. On severely attacked tubers, the spots coalesce, giving the tubers an appearance of shrinking (Fig. 2.). No mycelium of spores appear on the surface of the tubers, but from 60 to 70% pure cultures can be obtained by washing the surface with Mercuric Bichloride and removing pieces, with a flamed scalpel, to sterile tubes. The contamination found in our cultures were nearly always Penicillium and Mucor, while occasionally it was Bacterial.

On potato dextrose agar, the mycelium is at first grayish white, copius and fluffy. In two weeks, it turns olive green in color with a grayish white border (Figs. 3 and 4). In six weeks, it becomes iron gray with a greenish gray border. The spores are muriated, from two to twenty or more cells, brownish in color, and, as a rule, produced singly, but two catenulate spores have often been found. (Fig. 5.) The substratum on which the fungus grows turns black in about two weeks.

Three different inoculations on five healthy potato plants, including three varieties, namely, Green Mountain, Irish Cobbler and Carman No. 3., gave negative results. The inoculations were made by watering the plants with a spore suspension, and keeping the plants in a very moist condition under bell jars from 36 to 48 hours. Potato tubers kept at room temperature were inoculated by cutting with a flamed scalpel. and inserting spores. Abundant mycelium and spores were produced, but the fungus did not enlarge the wound. The fungus grew on sterilized potato, carrot, beet, parsnip, turnip, tomato, orange and apple slants and on sterilized cabbage and lettuce

leaves. On sterilized beet leaves, potato stalks tomato stems and cucumbers, inoculations gave negative results.

From the fact that catenulate spores were found in cultures, and that the fungus will grow on a variety of things, like sterilized carrots, beets, turnips, parsnips, tomatoes, oranges cabbage and lettuce, while it will not infect living potato plants, it is temporarily called *Alternaria fasciculata* (C. & E.) J. & G., as described by Jones in the report of the Vermont Agricultural Experimental Station, 1895. No spore measurements have been made so far, nor any comparative study of different culture media.

Gratz and Bonde, at the Kansas Meetings of the American Asssociation for the Advancement of Science (Abstract in Phytopathology, January 1926) report infecting potato tubers by rolling them in leaves spotted with *Alternaria solani*. According to Jones, as cited above, Alternaria fasciculata is almost always associated with Early Blight on potato leaves, and as no culture of the organism seems to have been made by Gratz and Bonde, it may be questioned of it was really Early Blight that caused the lesions on their tubers.

The tubers on which this fungus was found were left in bags in a comparatively warm part of the basement for about two weeks. The more severely attacked tubers show definite signs of having heated. It is presumed, until further work is made, that heating of tubers at the time of harvesting is conducive to its development. The control of the disease, therefore, would be in taking better care of the tubers at the time of harvesting and storing them immediately in a cool and well-ventilated place.

SMUT DISINFECTANTS IN 1926.

J. G. Coulson

As in previous years experiments were continued to test the efficacy of various disinfectants against smut, using Liberty oats which were artificially inoculated to the extent of over 50 per cent of smut in check plots. The plots were each of three rows, the rows a rod in length, and each experiment was triplicated.

Grain was treated and sown (as in past years 1, 2) on May 13th when the temperature was 58oF and soil moisture 22.42%. Soil moisture varied from 14.8% on May 18th to 31.8% on May 21st, these being the minimum and maximum respectively for the season.

The table summarizes the results by count of plants.

Treatment	Smut percentage average of 3 plots
Disinfectant No. 16 (DuPont)	0
Disinfectant No. 13 (DuPont)	7.3%
CuSO4 and Lime	0
Nickel Sulphide	0
Nickel Hydrate	0
Copper Tartrate	0
Disinfectant No. 30 (DuPont)	10.1
Check	53.8
Copper Carbonate Dust	0
Semesan Soak (DuPont)	0
Uspulum	1.2
Semesan Dust (DuPont)	1.2
Formalin	0
Nickel Carbonate	3.7

Bibliography.

1. Dickson, B. T., R. Summerby and J. G. Coulson.
Experiments in the control of oat smut. Q. S. P. P., 15: 102-105, 1923.

2. Dickson, B. T.
Oat smut control experiments in 1923. Q. S. P. P., Rept. 16; 77-79, 1924.

3. Dickson, B. T.
Oat smut control in 1924. Q. S. P. P., Rept. 17: 35-36, 1925.

SOMES NOTES ON MAIZE RUST IN THE PROVINCE OF QUEBEC.

By Richard F. V. Cooper

During the late summer and early fall of 1925 the writer had the opportunity of watching an unusually heavy infection of rust on the sweet corn (Golden Bantam)grown in the experimental plots of the Botany Department of Mcdonald College. While this disease has never been known to cause economic loss, conditions during the last two or three years seem to have been favorable to its spread in Canada. In 1922 it was common in Manitoba but was not observed in any other part of the Dominion according to the Dominion survey. Mr. Dimmock of the Harrow (Ont) Station has informed the writer in conversation that infection was heavy in his district during 1924, but was not so noticeable in 1925; he had no knowledge of conditions previous to 1924. The first record of the disease at Mcdonald within recent years was in 1925 on sweet corn, as already stated, and to a lesser extent on field corn The writer does not wish to imply an eastward trek from these examples but quotes them merely to show that apparently maize rust has been becoming common in districts where it had not recently been observed.

Enough has been said to make a short description of the maize rust fungus, *Dicaeoma Sorghi* (Schw.) Kuntze, of topical interest and to furnish an excuse for a few speculations on its overwintering in Quebec.

In 1832, L. von Schweinitz described a telial rust which he observed at Bethlehem, Pennsylvania, *in foliis Sorghi et Zeae cultae.* (1) Without cross-inoculation experiments it is apparent that Schweinitz had no justification for assuming the identity of the rusts on Zea and Sorghum, and apparently his work has never been verified as Arthur in North American Flora (2) does not even mention Sorghum among the hosts of *Dicaeoma Sorghi.* To date the writer has not been able to infect Sorghum with maize rust, though he has not performed sufficient inoculations to make any statement conclusive.

The uredinial stage of *D. Sorghi* was described and named *Uredo Zeae* by Desmazieres in 1840, but it was not until 1904 that Arthur proved by inoculation that the Oxalis Aecidium of Thuemen and others (A. *Oxalidis Thuem.*; *A. Peyritschianum* Magnus) was the alternate form of maize rust. (3) In North American Flora (2) he mentions four Oxalidaceous hots, as follows:

Ionoxalis violacea (L.) Small.
Xanthoxalis filipes Small.
X. Langloisii Small.
X. stricta (L.) Small.

(Ionaxalis and Xanthoxalis have been constituted from the Linnaean genus Oxalis by Small in his new classification of the Oxalidaceae in North American Flora 25:1: pp. 24–58)

In addition to the above, Peyritsch's Aecidium was found on *X. corniculata* (L.) Small in the Tyrol (Austria) in 1893 and has since been identified with *Dicaeoma Sorghi* by Arthur. (1)

M. A. Smith (4) adds the following names to Athur's list hosts—

Oxalis corniculata (X. corniculata).

O. Europea.

O. tropaeloides.

The writer has not been able to trace the two latter species. They are not mentioned in North American Flora either directly or as synonyms, and he is lead to the conclusion that they are exotic species.

The following is a list of species of Oxalidaceae which are recorded in North American Flora as existing in Canada or adjacent states of the Union; notes on their rust-susceptibility have been added:—

Oxalis acetosella L. No infection recorded. (the common wood sorrel).

Ionoxalis violacea (L.) Small. Susceptible-Arthur. Occurs in Northern United States, not known to occur in Canada.

Aecia and pycnia of D. sorghi on the lower surface of a leaf of Xanthoxalis corniculata. (original. x diam)

Xanthoxalis stricta (L.) Small. Susceptible-Arthur. This species may be readily distinguished by the remarkable size of the epidermal cells of the leaflets, a feature which may be observed with the aid of a ten-diameter hand lens. It is common in the neighbourhood of Macdonald College and is the only susceptible species in the Macoun Herbarium preserved at Macdonald.

Xanthoxalis corniculata (L.) Small. Susceptible in Europe (Peyritsch); in U. S. A. (Smith)in Canada (Cooper). This species is said to be naturalized in Ontario. It is common greenhouse weed in Quebec.

Xanthoxalis cymosa Small. Susceptibility doubtful.

It will be seen that if aecial infection of *D. Sorghi* occurs in Quebec under natural conditions that the host is probably either *X. stricta* or *X. corniculata*. While the writer has satisfied himself that the latter is highly susceptible to artificial inoculation, he is not aware of any greenhouse practice which would bring infected corn-leaves into contact with the oxalis growing in beds and flower pots. The possibility of soil containing morsels of infected stubble being used for potting seems too remote for consideration. *X. corniculata* is exceedingly common in the College greenhouses but the writer has never collected aecia anywhere but in the immediate vicinity of the teliosporic material laid down by him.

Before leaving the discussion of the aecial host a short description of the pycnial and aecial stages may be of interest.

Within 2½ to 3 weeks of placing teliosporic material on the soil in their pots, oxalis plants (*X. corniculata*) begin to show signs of infection. First considerable areas of the leaflets become etiolated, and pycnia begin to appear. The pycnia are reddish yellow and are irregularly scattered, principally, hypopyllously, but to a lesser extent epiphyllously and on the petiole. They are in the neighbourhood of 1/10 mm. in diameter.

The aecia appear within a week of the appearance of the first pycnia. They are entirely hypophyllous, in irregular groups, becoming conspiceous through the presence of large numbers of golden-yellow spores. The spores are minutely verrucose, irregularly spheroid and average 18 by 20 micra. The aecia are from ½ to 1 3 mm. in diameter. Under conditions of excessive moisture the writer has observed that the peridia of old aecia may become infested with a species of Alternaria.

It is usually accepted that Zea is a native of Central America. It is only natural to suppose that *D. Sorghi* arose in the same part of the world and this supposition is borne out by the fact that the majority of North American Oxalidaceae occur only in the tropics and subtropics, many being known only from their type locality. According to the general theory of Age and Area (5) the presumption then is in favour of the Oxalidaceae being long established in Tropical America.

It is impossible to believe that all infections of maize rust are initiated by an aecidial stage so rare as the oxalis rust. The possible overwintering of uredospores in the Northern United States and Canada seems to have been disposed of by Smith (4) who shows that "only a trace" of germination was observed in March when uredospores had been exposed to the winter conditions of the State of Iowa and that after mid April no germination occurred. The writer believes that he has seen one uredospore germinating in March after being exposed to Quebec conditions, but even after surviving the winter

it is hard to see how a spore could remain ungerminated long enough to initiate infection of maize in June for, according to the same author and to several other investigators the optimum temperature for the germination of the uredospores is in the neighbourhood of 18° C. (64°–65° F.) a temperature which is invariably recorded many times in late spring before maize is above ground.

From the above considerations the writer is driven to the conclusion that epidemics of maize rust in Canada are initiated by invasions of uredospores from the south and that the aecial stage plays no serious part in the initiation of infection in these latitudes.

Summary

The writer discusses the known aecial hosts of *D. Sorghi* occurring in Quebec, dismisses the likelyhood overwintering uredospores under Canadian conditions and concludes that infections of maize in Quebec are caused largely, if not entirely, by uredinial invasions from the south.

A short description of the aecial stage produced for the first time under Quebec conditions on *X. corniculata* (L.) Small is included in the discussion.

Acknowledgment

The writer desires to acknowledge his indebtedness to Dr. B. T. Dickson for much encouragement and helpful criticism.

Bibliography

1. Schweinitz, L. D. von, Synopsis Fungorum in America Boreali, etc. Trans. Amer. Phil. Soc. 4: pp. 141-136o. Philadelphia, 1834.
2. North American Flora 7: 4: p. 277. The New York Botanical Garden, Dec. 24, 1920.
3. Arthur, J. C. "The Aecidium of Maize Rust". Bot. Gaz.: 38: pp. 64-67.
4. Smith, M. A., "Infection and Spore Germination Tests with P. Sorghi". Phytopath. 16: 1: p. 69. 1926.
5. Willis, J. C. Age and Area, a study in geographical distribution and origin of species. 259 pp. Cambridge University Press, 1922.

o The writer has only seen Schweinitz' diagnosis of *P. Sorghi* transcribed from this paper through the kindness of the Reasarch Council of Washington.

PLANT DISEASES IN THE KAMOURASKA REGION—1924-1925

By Prof. E. Campagna and Fernand Godbout, B.S.A.

In order to obtain an idea as to the principal plant diseases occurring in the Kamouraska region, we have thought it well to compile a list of such diseases as we have observed during the seasons 1924–25.

Specimens which we were doubtful of were sent for indentification to the Division of Plant Pathology, Bureau of Plant Industry, Washington, D. C., or to other departments of Plant Pathology.

The diseases mentioned in this report have been classified in the following order.

(a) Cereal diseases.
(b) Diseases of field crops.
(c) Fruit diseases.
(d) Diseases of ornamental and forest trees.
(e) Diseases of ornamental plants.
(f) Diseases of other plants.

Cereals

WHEAT.

Naked Smut (*Ustilago tritici* (*Pers*) *Jens.*)
Separately distributed throughout the country. In certain fields of the Ste Anne's Agricultural School farm, infection was more noticeable.

Black Stem Rust (*Puccinia graminis Pers.*)
As usual, wheat is subject to severe attacks from this rust.

Leaf Rust (*Puccinia triticina, Erikss.*)
Not as severe as the preceding but of general distribution.

OATS.

Naked Smut (*Ustilago avenae* (*Pers*) *Jens.*)
In certain localities infection was common.

Covered Smut (*Ustilago levis* (*K. & S.*) (*Mag.*)
Not as evenly distributed as the preceding.

Black Stem Rust (*Ustaligo nuda* (*Jens*) *K. & S.*)

BARLEY.

Naked Smut (*Ustilago nuda* (*Jens*) *K. & S.*
Infection less than 2%.

Covered Smut (*Ustilago hordei* (*Pers*) *K. & S.*)
This disease was also found in places. (Ste Anne de la Pocatière).

Black Stem Rust (*Puccinia graminis* (*Pers*).
Certain fields of barley were subject to very severe attacks.

RYE.

Ergot (*Claviceps purpurea* (*Fr*) *Tul.*)

CORN.

Smut. (*Ustilago z ae* (*Berk*) *Ung.*)
Found in traces in the Ste Anne's Agricultural School farm.

Field crops

A. LEGUMES.

LUCERNE.

Leaf Spot (*Pseudopeziza medicaginis* (*Lib.*) *Sacc.*)
Widely distributed in Ste. Anne but not very injurious.

CLOVER.

Powdery Mildew (*Erysiphe polygoni D. C.*)
A very common disease.

Rust (*Uromyces trifolii* (*Hedw.*) *Lev.*)

Sooty Spot (*Phyllachora trifolii* (*Pers*) *Fckl*)
(*Polythrincium trofolii Kunze*).

Usually widely distributed but of no economic importance.
Leaf Spot (*Pseudopeziza trifolii, Bain*).
Anthracnose (*Colletotricum trifolii, Bain*).
Mosaic (*Cause unknown*).

VETCH. *Rust* (*Uromyces fabae, Pers*)—(*Uromyces crobi, Pers*).
Very widespread in a field of the school-farm.

B. GRASSES.

MILLET. *Rust* (*Puccinia phlei-pratensis, Erikss & Henn.*)
Smut (*Ustilago striaeformis* (*West*) *Niessl.*)
Ergot (*Claviceps purpurea* (*Fr.*) *Tul.*)

VARIOUS GRASSES.
Puccinia graminis, Pers.
Cock's Foot (Dactylis glomerata L.)
English Ray-grass (Lolium perenne L.)
Western Ray-grass (Agropyron tenerum, Vasey).
Dog-tooth (Agropyron repens (L) Bauv.
Claviceps purpurea (*Fr.*) *Tul.*
Cock's Foot (Dactylis glomerata L.)
English Ray-grass (Lolium perenne L.)
Western Ray-grass (Agropyron tenerum, Vasey).
Dog-tooth (Agropyron repens (L) Bauv.)
Phyllachora graminis (*Pers*) *Fckl.*
Dog-tooth (Agropyron repens (L) Bauv.)
Erysiphe graminis D. C.
Dog-tooth Agropyron repens (L) Bauv.)

VARIOUS CROPS.

SUNFLOWER. *Rust* (*Puccinia helianthi Schw.*)
Infection from 70-80% on the Ste. Anne School Farm.
Stem Wilt and Rot (*Sclerotinia sclerotiorum*).

Diseases of fruit trees

APPLE TREES. *Scab* (Venturia inequalis (Cke) Wint.)
Spraying is effective in preventing this disease.
Black rot (Physalospora cydoniae, Arnaud.)
(Sphaeropsis malorum, Peck.)—
A disease of little economic importance.

PLUM TREES. *Black knot* (Plowrightia morbosa (Schw) Sacc.
This disease occurs chiefly in old neglected orchards.
Bacterial leaf-spot (Bacterium pruni E. F. S.)
One case observed in Ste. Anne.
Shot-hole (Coccomyces hiemalis, Higg).
Not wideley distributed.

CHERRY TREES. *Shot-hole* (Coccomyces hiemalis, Cigg.)
Black Knot (Plowrightia morbosa (Schw) Sacc.)
This disease is widespread among the wild cherries; uncommon in well kept orchards.

PEAR TREES.	*Bacterial Blight* (Bacillus amylovorus (Burr) Trev.) "In a young orchard of twenty trees, H. N. Racicot).
STRAWBERRIES.	*Leaf Spot* (Mycosphaerella fragariae (Schw Lind.) Evenly distributed. *Leaf-blight* (Marssonina potentillae Desm.) Fisch.
CURRANT.	*Rust* (Cronartium ribicola) Eisch von Wald). Very common disease; the stage on the pine tree has not been observed again in spite of active searches.
RASPBERRIES.	Moasic (Cause unknown.) *Crown Gall* (Pseudomonas tumefaciens (Sw) Dororis).
GOOSEBERRIES.	*Rust* (Puccinia pringsheiminan, Kleb.) *Powdery Mildew* (Sphaerotheca mors-uvae, (Schw) B. & C.) One case encountered in Ste Anne; considerably injurious.

Vegetables and highly cultivated plants.

ASPARAGUS.	*Foot rot* (Rhizoctonis solani).
BEANS.	*Anthracnose* Colletotrichum lindemuthianum (Sacc & Magn.) Br. & CA). Of general occurrence; in certain places infections as high as 20 % and even 40%. *Bacterial blight* (Bacterium phaseoli E. F. S.) Isolated cases. *Sclerotinia rot* (Sclerotinia libertiana, Fckl.) This disease appears to be more and more destructive to several plants during the past few years. *Mosaic* (Cause unknown). *Powdery Mildew* (Erysiphe polygoni, D. C.) This mildew is not very common.
RHUBARB.	*Leaf spot* (Phyllosticta straminella, Bres.) Although widely distributed, this disease is not of any economic importance.
TOBACCO.	*Leaf Blight* (Cercospora nicotianae Ell & Ev.) One case was reported: traces.
TOMATOES.	*Early Blight* (Alternaria solani (E & M) J. &G.) Widely distributed throughout the country. Considerable injury done to the garden of the Agricultural School.
TURNIPS.	*Club-root* (Plasmodiophora brassicae, Wor.)
CHIVES.	*Ink spot* (Vermicularia circinans, Berk) (Colletotrichum circinans).
LEEK.	*Wilt* (Vermicularia circinans, Berk)— (Colletotrichum circinanas). A disease of little economic importance excepting for certain years.

PUMPKIN.	*Leaf Spot* (Alternaria cucurbitae, Let). A disease widely distributed in Ste. Anne.
BEET.	*Leaf Spot* (Cercospora beticola, Sacc.) Generally distributed. *Gall* (Actinomyces scabies (Thax) Gussow) Several cases of this disease were reported last Fall.
CABBAGE.	*Club-root* (Plasmodiophora brassicae, Wor) *Soft rot* (Bacillus carotovorus, Jones) *Black Vein* (Bacterium campestris (Pammel) E. F. S. Infection about 5% in the garden of the Agricultural School *Leaf Spot* (Alternaria brassicae (Berk) Sacc.) This disease is not very destructive. *Wilt* (Sclerotinia libertiana, Fckl.)
CAULIFLOWER.	*Black Vein* (Bacterium campestris (Pammel) E.F.S.) About 6% in the Agricultural School garden.
CHOUX DE SIAM* (KHOL RABBI ?)	*Club-root* (Plasmodiophora brassicae, Wor.) *Leaf Spot* (Alternaria brassicae (Berk) Sacc.) This disease was widely distributed in several places on the farm of the Agricultural School. * French.
CELERY.	*Bacterial Blight* (Bacterium apii, Jagger) Observed for the first time in 1923; it is sometimes quite destructive. *Early Blight* (Cercospora apii; Fr.) *Late Blight* (Septoria petroselini (Desm) var apii, (Br. & Cav.) Seen for the first time last Autumn.
PEAS.	*Rust* (Uromyces pisi (Pers) Wint.) Found each year in the garden of the School of Agriculture. *Ascochyte Blight* (Mycosphaerella pinodes, Stone) Very destructive in 1924 but less common in 1925. *Mildew* (Erysiphe polygoni, D.C.)
POTATO.	*Late blight* (Phytophthora infestans, de Bary) *Early blight* (Alternaria solani (E. & M.) J. & G.) (Macrosporium solani, E. & M.) *Black arm* (Bacillus atrosepticus, Van Hall.) *Common Gall* (Actinomyces scabies (Thax) Gussow. *Tip blight* (Insect) Empoasca mali. *Mosaic* (Cause unknown.)

Diseases of ornamental and forest trees

CHESTNUT. (Castanea dentata (March) Borkh.)
Blight (Endothia parasitata (Murr) And.

MAPLE. (Acer. sp.)
Black spot (Rhytisma punctatum, Eries.
A disease widespread in Ste Anne.
Leaf spot (Phyllosticta acericola, C. &. E.)
(Phyllactinia corylea, Pers.)

POPLAR (*Populus sp.*)
Powdery Mildew (Uncinula salisis (D.C.) Wint.)
A disease widespread and very injurious.

WILLOW. (Salix humilis, Marshall)
Tar spot (Rhytisma salicinum, Fr.)
Powdery Mildew (Uncinula salisis (D.C.) Wint.)
As widespread as on the Poplar but less serious.
Leaf spot (Gloeosporium salisis, West)=
(Pseudopeziza salisis (Tul) Pot.)

WILLOW. (Salis sp.)
Leaf spot (Septoria salicina).=(Septoria didima, Fuck.)

JUNEBERRY. (Amelanchier canadensis, Torr.)
Cedar rust (Gymnosporangium juniperi virginianae)
Aecial stage very widespread.

Diseases of ornamental plants

COMMON BARBERRY. (Berberis vulgaris).
Rust (Puccinia graminis, Pers.)

BUCKTHORN. (Rhamnus sp.)
Rust (Puccinia coronata, Cda.)
Found at Ste Anne de la Pocatière.

HOLLYHOCK (Althaea rosea, Cav.)
Rust (Puccinia malvacearum, Mont.)
Very destructive to this plant.

ROSES. (Rosa spp.)
Rust (Phragmidium sp.)

SNOW BALL. (Symphoricarpos sp.)
Mildew (Microsphaera diffusa, Cke & Pk.)

CARNATION. (Dianthus cariophilus, L.)
Leaf spot (Alternaria dianthi ,Stev. & Hall)
Found each year at Ste Anne.

LILAC. (Syringa vulgaris L.)
Leaf spot (Phyllosticta halstedii, E. & E.)
A single case was reported.

Diseases of other plants (unclassified)

BUCKWHEAT. (Polygonum persicaria, L.)
Leaf spot (Septoria polygonum, Desm.)

GOOSEFOOT. (Chenopodium album, L.)
Leaf blight (Cercospora dubia (Riess) Wint.)

PIGWEED. (Amaranthus retroflexus L.)
White rust (Albugo bliti)

COMMON PLANTAIN. (Plantago major L.)
Mildew (Erysiphe cichoraceum, D. C.)
Leaf spot (Ramularia plantaginis, E. & M.)

MALLOW. (Malva rotundifolia L.)
Rust (Puccinia malvacearum, Mont.)
Leaf blight (Cercospora althaeina, Sacc.)

DANDELION. (Taraxacum officinale L.)
Rust (Puccinia taraxaci (Rabent) Plowr.)
Leaf spot (Ramularia taraxaci, Karst.)

WILD STRAWBERRY. (Fragaria sp.)
Leaf spot (Micosphaerella fragariae (Tul) Lindon)
Leaf blight (Marssonia potentillae)—%
(Mollisia earliana).

SEDUM. (Sedum purpureum L.)
Leaf spot (Septoria sedi, West).

WILD CURRANT. (Ribes sp.)
Rust (Cronartium ribicola).

AGRIMONY. (Agrimonia eupatoria).
Rust (Pucciniastrum agrimoniae).

BINDWEED. (Convolvulus arvensis).
Leaf spot (Septoria convolvuli).

ASTERS. (Aster sp.)
Rust (Aecidium asteris, Thum.)
Rust (Puccinia asteris, Duby.)
Mildew (Erysiphe cichoraceum).
Black spot (Phyllachora haydeni.)

BULRUSH. (Scirpus atrovirens).
Rust (Puccinia scirpi.)

TRUMPET WEED.	(Eupatorium purpureum.) *Mildew* (Erysiphe cichoraceum).
OX-EYE DAISY.	(Chrysanthemum leucanthemum L.) *Leaf spot* (Septoria cercosporoides, Trail.)
WILD MUSTARD.	(Sinapsis arvensis L.) *White rust* (Cystopus candidus (Pers) de Bary)
CANADA THISTLE.	(Circium arvense L.) *Rust* (Puccinia suaveolens, Pers.) *White rust* (Albugo tragopogonis).
BURDOCK.	(Lappa communis L.) *Rust* (Puccinia lappae).
SETARIA.	(Setaria viridis (L) Beauv.) *Mildew* (Erysiphe graminis D. C.)
VETCH.	(Vicia craccea, L.) *Rust* (Uromyces pisi).
VIOLET.	(Viola sp.) *Rust* (Puccinia violae, Schw.)
ELDEN ROD.	(Solidago lanceolata). *Tar spot* (Rhytisma solidaginis, Schw.)
IRIS.	(Iris versicolor, L.) *Rust* (Puccinia iridis)
WILD LETTUCE.	(Sonchus arvensis). *Rust* (Puccinia taraxaci). *Leaf spot* (Ramularia taraxaci).

THE CONDITIONS OF ORCHARDS AROUND QUEBEC

By Omer Caron, Botanist, Dept. of Agriculture, Quebec.

During the summers of 1924-25, we inspected a number of orchards in the vicinity of Quebec. Our observations were made in the counties of Quebec, Montmorency, Beauce and Arthabaska. The conclusions we have arrived at after the hasty examination of about two to three thousand trees, may not be of great value to fruit growing, economic entomology, or (plant) pathology; but as the object of our survey was to gain information regarding the condition of the trees, we think it worth while to give a review of our observations.

I know from experience that from a protection point of view, the trees in

the eastern part of the province are no worse than those of the region around Montreal; so that in speaking of the former, I do not wish to infer that they are any better cared for, nor more neglected, than the latter.

We pathologists are primarily on the lookout for troubles; so that there may be some excuse for our reputation as pessimists, Our duties are like those of medical men who do not merely care for sickness by prescribing medicines; we must, like them, not only try to cure disease but also prevent it as much possible. Hygiene is necessary in plant pathology as in human pathology, and in practicing reasonable hygenic methods, soundly based on plant physiology, we shall be doing a greater service than in prescribing methods of control which the fruit grower accepts unwillingly, as being suggestive of a prescription patent medecine.

We must also take into consideration the mentality of our clients, who have only recently become acquainted with the plant pathologist. We have often observed that the apple grower who looks after his trees and gives them the protection which they are in need of, will readily admit that his trees should be sprayed at the right time, whilst it is useless to speak of spraying at one who does not even take the trouble to prune and clean his orchard.

Our observations have been chiefly on the physiological aspects of the diseases noticed. Vigorous trees are rarely sick and where we have seen different diseases in some orchards, we agree with all the authorities on this subject that, harmful bacteria or fungi only develop in weakened or injured tissues.

Whilst we have found in certain orchards diseases dangerous to trees, this has always been coincident with some fault in the soil, drainage, situation or food supply.

A brief account of the general observations we made in our tour of inspection is here given.

In the vicinity of Quebec, apple trees between 10–15 years old are in a bad condition. These trees are actually passing through a critical period, as are most of the varieties observed. Amongst the commercial varieties no one in particular seems to have been much more resistant than the others.

We must remember that the very severe winters which we had in 1917 and 1918 were probably the first cause of the weakness of the trees which had been recently planted. Amongst other causes, lack of care is the principal one which has been added. We have now to deplore this disastrous condition, whilst waiting for the death of our trees. The older trees are in better condition.

We were pleased to find that in several districts our methods of protection, based on cleaning and cultivation are showing results, and are noticeable wherever they are praticed.

It is generally not necessary for us to ask the grower whether he sprays or not, a brief inspection of his orchard tells us this.

The more common diseases seen on our trees are sun scald, bacterial blight, collar rot and several kinds of canker.

Sun scald.

Bright sunny days in spring followed by hard frosts result in considerable losses in our orchards. We have seen orchards in which the annual repetition of this phenomenon has soon caused the death of a large number of trees, resulting in no small financial loss to the owners.

In localities naturally favorable for orcharding the choice of a better situation, and the annual or semi-annual application of line to the trees would certainly have the lessenedeffects of sun scald. Our growers in spite of the advice we have given, have persisted in planting their trees in bad situations, with the result that after 10 or 15 years of careless orcharding, which must also be taken into consideration, they lose all their labour, as everything must be done over again. Instead of making progress, they have not even remained stationary but have retreated. From a technical point of view you know all the evil results which follow; the bark dries out, the circulation of the sap is hindered and all kinds of cankers cover the trees to cause their death sooner or later.

Fire blight.

In the district of Arthabaska, we have found many cases of fire blight. The growers do not seem to pay much attention to this serious disease, and we have wondered if we are not mistaken, in spite of the very apparent and recognizable symptoms of fire blight. In several doubtful cases we have transferred some cambium from the infected trees to potato-dextrose agar. By so doing we nearly always obtained a bacterial culture which though we did not study it closely, resembled B. *amylovorus* in its more important characteristics. We have therefore good reason to believe that the suspected specimens were examples of fire blight.

The incompleteness of this technical work does not counteract the symptoms observed in the trees the previous summer, and we maintain that fire blight is doing a great deal of harm to the orchards in this district.

Collar Rot. It this same district of Arthabaska, we have seen in several orchards trees dead, or dying, which at first sight showed no apparent cause for this condition. The buds were normal and apparently healthy. Closer examination showed us that the trunk including the cambium layer was rotted just above the ground level, and that this had brought on the death of the trees. This rot is serious in orchards where the drainage is poor.

Cankers. We cannot give any exact information on the nature of the fungi which cause the characteristic marks and depressions which are known as cankers. We believe, however, that this type of disease is of sufficient importance to be mentioned in this paper. We have found chancres prevalent wherever the trees lack vitality or have not been given proper attention.

Conclusion.

It is concluded from these observations that in the eastern part of the province our apple trees are far from being in a satisfactory condition.

We have observed that this evil is due chiefly to lack of proper orcharding methods, with all that this implies. I have drawn attention to this state of affairs so as to invite those among you who come in contact with the apple growers, to help us in the campaign of education which is very necessary.

If any one amongst you is interested in the diseases of apple trees, I think we shall be able to supply him with plenty of material to study. In this connection, I wonder if it is not possible to do for the Society for the Protection of Plants, what has been done for the Pomological Society; that is, organize summer reunions not only in the district of Montreal, but also for that of Quebec. All those interested, technicians and agriculturalists could profit by these reunions.

"NEW WHITE SMUT" OF WHEAT, COLLECTED AT STE. ANNE DE LA POCATIERE.

Prof. E. Campagna, Ste Anne de la Pocatière.

Last July, one of our graduating students who was working (M. Daniel Pomerleau) at the Ste. Anne Experimental Station, brought me one day, an awn of wheat which was attacked by a most interesting disease. The collector gave me the specimen saying that he had found "white smut" on wheat, that he did not know if it was very uncommon, but that he would like me to study and identify the disease . . or him, if I had time.

After a summary examination, I told him that this supposed "white smut" seemed rather uncommon to me.

Morphologically, the specimen. showed all the symptoms of the ordinary loose smut of wheat. The awn was totally out of the ochrea of the last leaf and had been eaten away by the pathogen. As in the loose smut, the genital organs of the flower, the husks or glumes, had been totally transformed into powdery mass of whitish colour; the stalk (rachis) alone being intact. The stem was just a bit shorter than the neighbouring plants which were unattacked. The specimen was collected in a Huron wheat field and belonged probably to this variety, for, on the diseased awn, we could still observe remains of beards, which are caracteristic of Huron wheat. Regarding the external morphology, the specimen differed from the loose smut by the fact that the spores *instead* of being black were white.

Spores were taken on different parts of the diseased awn and were examined under the microscope. The spores were all colourless and nearly transparent. They were surrounded by a smooth and very thin tissue through which could be seen, inside the spores, several nuclear or particulate granulations.

The spores measured 4 to 8 microns with an average of 6.4 microns. They were spherical, or subspherical in shape, except a few which were oval or elongated.

Many questions are raised by this diseased wheat awn: I. Is this specimen attacked by the loose smut of wheat. which disease has not reached its full development? 2. Is it a new disease or one that is known only to foreign countries? 3. Is it simply a case of mutation or sudden variation?

The principal volumes treating of the "Ustilaginaeael" and other diseases of wheat were consulted. But no mention was made of a disease of that kind or of the "white smut" of wheat.

The specimen was then mailed to the Department of Pathology of Washington, and the reply stated that this disease was new to the various specialists and mycologists of their Department. This statement of expert mycologists of Washington allows us to think that the disease is rather uncommon and that it is not merely an immature stage of the loose smut of wheat, as no doubt it would have been noticed before.

Now, let us suppose that this is a new parasite, which is not proven; the pathogenicity and stability of the organism should be established. No inoculation experiment was tried on other wheat blossoms to determine if the spores would germinate and develop when placed in ideal conditions. This research work was unavoidably delayed, as there are no greenhouses at our disposal for growing wheat during the winter. However the survey will be continued next summer.

In order to determine the viability and pathogenicity of the spores, germination tests were made in water or different cultures as suggested in Bull. 73, by Mr. H. T. Gussow, on Smut diseases of cultivated plants, but no results were obtained. At the Department of Pathology of Washington, the germination tests were also fruitless. Therefore, nothing can be said about the pathogenicity and still less of the stability of the organism. It is perhaps a case of mutation or sudden variation; it would then be impossible to have results with the inoculation. In a way, it would be far better that the germination should fail, as we would have to record a new disease of wheat, and these are surely numerous enough.

Next summer, the Huron wheat fields where we may chance to meet some more specimens, will be observed, and if some are collected, we will be happy to send specimens to members of the Society of Plants Protection who are interested in the study of diseases of wheat.

PLANT PATHOLOGY IN FRANCE

By Richard Bordeleau, Ste Thecle, Que.

In discussing plant pathology in France I prefer to divide the subject into two parts dealing respectively with the organization of plant pathology and the workers engaged in plant pathology.

I.

Actual organization of plant pathology.

The institutions devoted to plant pathology in France may be divided into three groups.

A—Institutions of the Department of Agriculture.
B—Institutions of the Department of Public Instruction.
C—Private institutions.

A—Institutions of the Department of Agriculture

These may be grouped into two types. On one hand the Research Stations and on the other the Teaching laboratories.

Research Stations.

a—Paris' Plant Pathological Station.

In 1887, Prillieux, considered as the father of plant pathology in France established the plant pathology laboratory at l'Institut National Agronomique. In 1898 he obtained enough funds to develop his laboratory which was transferred to Alesia Street. From 1898 to 1909 the director was Delacroix with Joffrin and Maublanc as assistants. From 1909 to 1912 Prillieux was director with Griffon and Maublanc assisting. From 1912 to 1915 Etienne Foex took the place of assistant-director. At the death of Prillieux in 1915, Etienne Foex who was at that time on war service was elected director, but it was not till 1919 that he functioned. G. Arnaud became assistant-director and in 1922 director-adjoint. In 1921 the Paris Plant Pathological Station was attached to l'Institut des Recherches Agronomiques which was created at that time and to which were annexed all the stations and Laboratories of the Department of Agriculture. In 1923 the following workers Miss Barbier, Miss Gaudineau and M. Guyot joined the service. Miss Barbier took charge of the Collection and Miss Gaudineau of the Library. At the same

time Miss Gaudineau worked in co-operation with M. Guyot on a disease of wheat caused by two fungi, Leptosphaeria and Ophiobolus. In the same year the Paris Pathological Station changed its name to the *Station Centrale de Phytopathologie et de Parasitologie Agricole.* The station will be soon transferred to Versaille in a new building.

b—Brive Plant Pathological Station.

In 1921 Dufrenoy entered in the service and devoted himself to the Ink disease of chestnut by Melaconis modonia and he was named director of a special laboratory founded at Brive (Correze), for the study of this disease.

c—Bordeaux Plant Pathological Station.

The Grape Research Station of Cadillac which is well-known by reason of the work of Capus was in 1913 changed to a Plant Pathological Station, and was transferred after the war to Grande-Ferrade near Bordeaux. In 1923 Capus has been replaced by Gard, Professor in Bordeaux University. M. Gard is especially interested in grape and in walnut diseases.

d—Antibes' Plant Pathological Station.

At Antibes (Alpes Maritimes), a plant Pathological Station has been added to l'institut des Recherches Agronomiques. M. Poirault is in charge of the Station.

The following Schools of Agriculture and Agricultural Stations have also a plant pathologist on their staff, Metz, Nancy, Colmar, Dijon, Clermont-Ferrand, Avignon, Bel-Air, Montpellier.

The director of the Central Plant Pathological Station of Paris exercices a certain supervision the work of all the different pahologists.

Teaching Laboratories.

The Institut National Agronomique has in its program a plant pathology course given by Professor Fron.

In the National Schools of Agriculture plant pathology is taught by the professor of Botany, at Grignon by Ducomet, at Montpelier by khunoltz-Lordat, and at Rennes by Duboys.

In the Practical Schools of Agriculture the professors of Natural Sciences give some attention in their courses to plant pathology.

B—Institutions of the Department of Public Instruction.

Although no special course is given at the Museum, the study of plant pathology has always a place in the cryptogamic laboratory. We must recall attention to the work of Cornu and the more recent one of Mangin.

Plant Pathology is on the program of the departments of Botany in all the Universities.

Villedieu, professor in the Faculty of Medecine and Pharmacy of Tours and Fonze-Diacon, professor in the Faculty of Pharmacy of Montpellier, have done considerable work on the fungicides.

C—Private Institutions.

Vermorel, manufacturer of farm implements, has his own laboratory of plant pathology at Ville-Franche sur Saone. Important studies have been made by Vermorel himself or in co-operation with his assistants Dantony and Zolostarewsky on insecticides and fungicides.

Truffaut of Versailles has a special laboratory directed by Nicolas Bezssaronoff. The principal works are on the biology of the soil, but special attention is given to insecticides and fungicides.

The well-known seed growers, Vilmorin et Ciemhas have at Verrieres their own laboratory on plant pathology directed by M. Simonet.

SOCIETIES IN CONNECTION WITH PLANT PATHOLOGY.

1.—La Société Mycologique de France, founded in 1885 is largely responsible for the development of plant pathology in France. The society by its Bulletin gives to the research men in phytopathology an opportunity of publishing their works. In fact the Bulletin gave so much attention to plant pathology that a certain number of mycologists did not approve of the large place taken by this science in their Bulletin.

2—So, in 1914, all those interested in plant pathology founded the Societe de Pathologie Vegetale, which accepted as members pathologists, mycologists, entomologists, biologists, farmers etc. Prillieux, member of l'institut was responsible for the creation of the society, so he was elected Honorary president, with Mangin as active president, the secretaries were successively Hariot, Arnaud and finally Foex.

3—The Society of Comparative Pathology which is composed mostly of physicians and veterinary surgeons pays a little attention to plant pathology.

4.—In the Bulletin of the powerful Biological Society of France we can see notes on phytopathology.

5—The Annales de l'Institut Pasteur published the phytopathological papers of Laurent, Pinoy, Magrou and Picado.

6.—At Bordeaux there is a Zoological Society which published sometimes notes on plant pathology.

7.—Regularly at l'Academie des Sciences and at l'Academie d'Agriculture papers and reports on plant pathology are presented.

The principal workers in Phytopathology

To the XIX century.

The first work published in France on plant pathology was by Benedict Prevost on Stinking smut of Wheat in 1880. This work is remarkable by the precision of the morphology and life-history of the causal organism *Tilletia foetens*. Prevost was professor of Theology at Montauban (Tarne et Garonne). He was very much interested in Natural Sciences and in Phytopathology. If he is not the author of the method of the cupric treatment of seeds, his explanation of the mechanism of the action of this fungicide is very interesting. However, like many precursors he has been neither understood nor followed.

We can say that the great mycologists who succeeded in France during the nineteenth century, Desmazieres, Montagne, Tulasne Leveille, De Seynes, Cornu, Boudier, Patouillard have served by their works the future development of plant pathology. Pasteur's discoveries have been of great importance in the study of fungi and the new methods he introduced have been of great benefit to plant pathology as in other biologic branches.

The appearance of vine-yard pests like Oidium, Phylloxera, Mildew, Black Rot has contributed to orient many workers in mycology, botany, in plant pathological studies.

Powdery mildew of grape. (Uncinula necator).

In 1887 LaVergne et Mares brought the sulfur method of treatment into general practice. As is known this method was employed in England by Kyla in 1846, and in France in 1850 by Duchartre et Hardy.

Downy mildew of graphe. (Plasmopara viticola)

Observed in France for the first time by Planchon in 1878, this disease has been studied by Cornu, Millardet, Prillieux and Viala, Millardet was the first to find means of control of this disease in using bordeaux mixture.

Blackrot (Guignardia Bidwellii);

Black rot was found in France in 1885 by Viala and Ravaz. The principal studies on this disease have been made by Prillieux, Viala, Ravaz and Prunet.

Grape anthracnose. (Glaeosporium ampelophagum).

This disease has been especially studied by Cornu, Prillieux and Viala. The work of Viala and Boyer on "Grape Diseases" is a masterpiece.

Ink disease of the chestnut. (Melanconia modonia.)

This is of great economic importance in France, and Planchon, Delacroix, Crie, Mangin and many others have studied it.

Cereal diseases.

Prillieux has done considerable work on the subject and has published the results of his experiments in many reports. Prillieux and Delacroix worked on a disease of wheat caused by *Ophiobolus graminis*. Prillieux and Frechou worked in co-operation on *Peronospora setariæ*. Mangin continued the work of Delacroix and Prillieux on *Ophiobolus graminis*.

Potato diseases.

This plant of great economic importance has attracted the attention of excellent agronomists like Girard and Roze. This latter published in 1898 the "L'Histoire de la pomme de terre". It was shown by Prillieux ten years before the publication of Roze's work that it was possible to control *Phytophthora infestans* by Bordeaux mixture.

We have spoken above only of phytopathologists but we can not have the subject without saying a word on the mycologists who devoted themselves to problems in relation with plant pathology.

Cornu is well known for the work he has done on the Peronosporales, Ustilaginales, Uredinales, Grapes anthracnose and Late blight of potato. The classification of Boudier on European Discomycetes is still in use every day.

The Hymenomycetes have been studies by Patouillard and his researches on Polyporeae are not of less importance to plant pathologists.

De Seynes worked on the parasitism of Polyporeae.

Among the other mycologists whose works are very useful to plant pathologis we must place Mangin, Vuillemin, Gaston Bonnier, Poirault and Pecibouski.

XX Century

Prillieux. As well as to the Academie des Sciences as to the Academie d'Agriculture, Prillieux was regarded as representing the French phytopathologists. By his works he is more of the XIX century than of the XX century, for in 1900 he was 70 years old. At this time his eyesight did not permit him to work with the microscope, but he remained until his death, director of the Paris Plant Pathological station, interested in researches, and giving suggestions for new experiments. His good memory permitted him to recall his one-time co-operatiors, his oldest observations and publications. He published a great variety of works and attacked nearly all the subjects known at this time in plant pathology.

Boudier. More lucky than Prillieux, Boudier retained good eye-sight until his death in 1920. He was 90 years old. In the latter part of his life he was not able to do field collections, but he continued to study the specimens brought to him for identification.

Delacroix.—The best collaborator of Prillieux, Delacroix was responsible for considerable work until his death in 1909, He studied especially the tobacco diseases and worked successfully on plant diseases occurring in tropical countries.

He wrote a text-book on plant diseases, the first volume being on "Parasitic Plant Diseases of Cultivated Plants" and the second one on "Non Parasitic Diseases of Cultivated Plants". His vigour of mind, his considerable scientific work gave him a great place in the learned people. The practical utility of his works do profit greatly to the farmers of France and to inhabitants of tropical colonies.

Hariot. Published many memoirs on Mycology and plant pathology. He did especially valuable work on Uredinales.

Patouillard. Took the place of Camus in the Musem. In co-operation with Mangin he published many works on plant pathology.

Mangin. Actually member of l'Institut, Director of the Museum, Mangin is professor of Cryptogamy, which does not prevent him from spending time on plant pathology. He did interesting work on various subjects, especially on the chestnut disease.

Prunet. Professor of Botany at Toulouse University, Prunet did important studies on the grape diseases in general and particularly on the Black Rot (Guignardia Bidwellii); He did researches on a poplar disease caused by Cenangium populneum. At least he was the first to discover that grafting the other varieties of chestnut on the chestnut Castanea crenata made them immune to Ink disease caused by Melanconis modonia.

Viala. Grape grower himself, professor of l'Institut Agronomique, owner of the journal "La Revue de Viticulture", in close contact with all the French grape growers, Viala is considered an authority in this matter. For 20 years he persued researches on l'Esca, a disease of grape, caused by the fungus *Fomes igniarius* and others polyporeae. Certain of his interpretations, such as those concerning the relation between yeasts and the Gloeosporium have been a matter of discussion in which Guilliermond, whose wonderful works on yeasts are well known, too a great part.

Ravaz. While Viala was doing his experiments at Paris, Ravaz at Montpelier was studying with accuracy the grape diseases. Directly in contact with the grape growers, grape grower himself, he knew pretty well which were the exigencies of the practice and what the science must gave to it. The works which Ravaz published since 1900 attack all the questions of grape-growing. He conceived and realized a warning system based on the time of generation. of spores thus permitting the grape growers of the Montpellier country to do their spraying at the right time.

Capus. Established in Bordeaux country the same warning system for grape growers. During a great number of years. Capus studied the conditions favouring or permitting the development of Plasmopara viticola and Guignardia Bidwellii; He showed pretty well the relations between the parasite and its host. Deputy of la Gironde, Capus was, in 1926 named Minister of Agriculture, and has been obliged to renounce his researches on grape diseases.

Gard. Lecturer to the Bordeaux Science Faculty, Gard pursued the studies undertaken by Capus. He studied the conditions of germination of conidia

and zoopsores of Plasmopara viticola and the mechanism of the action of cupric treatments.

Boyer. Professor of Botany in the National School of Agriculture of Montpelier, Boyer, a very good observer, tried always to discover the scientific truth. He did researches on the diseases of olive and mulberry. He studied the fungus Helicobasidium purpureum living on grade. He was the professor of Ducomet, Arnaud, Foex, Chrestian, who took with him their laboratory practice.

Griffin. Assistant Director of the Paris Plant Pathological Station from 1909 until he died in 1912. His numerous works published alone or in co-operation with Maublanc, Foex or Berthault, prove his activity. He tried to verify by experiment if, as affirmed by Daniel, Professor of Botany to Rennes University, the graft is a true hybridization. His studies on this point pointed to conclusions different from those of Daniel.

Fron. Professor of Plant Pathology at l'Institut National Agronomique. He collaborated in many works with Prillieux and Van Tieghem. He worked on gooseberry diseases, on a disease of cotton and on a Chytridium parasitizing alfalfa.

Maublanc. Chief of Botanical and Plant Pathological works at l'Institut National Agronomique is at the same time general secretary of the Mycological Society of France. In numerous studies he has been collaborator of Prillieux, Delacroix, Griffin. Since his return from Brazil, Maublanc studied especially the colonial plant diseases.

Ducomet. Professor in the National School of Agriculture of Grignon, Ducomet is well known by his numerous publications on agricultureal botany, in genetics and in plant pathology. He worked at Rennes on the Ink disease of the chestnut. Since 1910 he has laboured especially on degeneration diseases of potato. This work is done with a practical point of view for he tried to get immune strains. He cultivated foreign varieties, he developed seed-plots and hybridizations. Ducomet studied the ecological actions on degeneration diseases. For two years, he has been studying cereal diseases and he has undertaken important experiments on rusts, the mode of hibernation and resistance of varieties.

Foex. Since 1915 Foex has been director of Paris Plant Pathological Station. His first researches were done on cereal rusts. Since 1924 he retook on larger basis a study on resistance to rust of a certain number of wheats which have been sown in eleven stations. In all these stations the seed-plots and observations are done on the same basis, in co-operation with Ducomet. He studied two diseases of wheat caused by Ophiobolus graminis and Leptosphaeria herpothricoides of which he studied well the conditions of germination f the ascospores. The control, for these diseases can be done by three differentways, first by the sulphuric acid treatment at 15% (recommended by Rabate), second, by amelioration of nutrition conditions of the plant (applications of nitrate of soda seem to give good results and third, in using resistant varieties we do not know much about the resistance of varieties against these diseases). Since the war, Foex, in co-operation with Ducomet, has studied the degeneration diseases. He tried to learn how these diseases are transmissible by the seed-

tuber and studied particularly leafroll. His experiments permitted him to conclude that the filosity disease was not transmissible by seed-tubers and consequently is not a degeneration disease. He worked on Erysiphaceae in general and especially on an Erysiphe which caused big loss on oaks. Foex followed with great interest the works of his collaborators: those of Dufrenoy, who, after Petri, believe the Ink disease of chestnut is due of *Blepharospora cambivora* and not by *Melancoris modonia;* those of Chabrolin working on orchard diseases in the Rhone Valley.

Arnaud. Adjoint-Director of Paris Plant Pathological Station. His principal works are: (1) "Studies on the Ordinary Fumagos".

The commonest fumagos are saprophytes belonging to varied groups, living in the honeydew of aphids.

(2) "Studies on Parasitic Fumagos.

These fungi parasitize like the Erysiphaceae but are dark in color. We find them mostly in tropical countries, but that which regulates their development is the humidity of the climate and that is why sometimes we find them in the mountains of Europe.

(3) "Studies on the Suction of the Homoptera."

This study is a completion of those of Prillieux on the Woolly aphis (*Schizoneur lanigera*).

(4) "Mulberry Diseases".

In collaboration with Lafont and Secretain, Arnaud worked on these diseases, especially on the biology of *Nectria cinnabarina* and on *Bacterium mori.*

(5) Various parasites and fungi.

A certain number of notes have been published under various titles and particularly on that of new and unknown diseases in France.

Bernard. By the ideas which he advanced on the transitions existing between parasitism and symbiosis, and on the mechanism of the action of a fungus on its host and on the reactions concerned, the works of Bernard are very interesting for the phytopathologists. We know how far this scientist generalized his theory in saying that all tuberization had for origin a root infestation. Having supposed that for potato, the tuberization was always the result of root, infestation, Bernard, by the study of facts, came to conclude that, culture, cold, etc., can have the same effect.

Magron. Chief of the laboratory of the Pasteur Institute, Magron pursued the works of Bernard. He showed by experiment that the root infestation plays a great role in the production of the tuberization phenomenon. Constantin tried to explain, either by the absence of root infestation, or by the action of high temperature the degeneration of the potato, and he proposed for control to cultivate it in cold climate. Magron for some time studied the crowngall, but the published little on the subject. In "La Presse Médicale" was published an article "Essai sur l'étiologie du cancer"; and in the "Annales de l'Institut Pasteur" a work entitled "Recherches expérimentales sur le cancer des plantes"; in the "Revue de Pathologie Végétale" he wrote "Tumeurs expérimentales dues au Bacterium tumefaciens".

Magron was Pinoy's collaborator (whose works on myxomycetes and on legume bacteria are well-known.)

Blaringhem. Professor at the Sorbonne, Blarighem worked in plant pathology. He has studied the rusts, working on heredity, resistance characters and sensitivity of varieties of wheat ot rusts.

Beauverie. Professor at Lyon. He studied the "web" disease which attacks seed-beds finding that the causal organism of this disease was a sterile form of *Botrytis cinerea.* He studied a poplar disease caused by a Gloeosproium, disease of peach-trees in Rhone Valley and rose diseases. In the tunnels of bark beetles or orchard trees, Beauverie found curious fungal forms named Ambrosia which are teratologic productions in relation with traumatisms. He made a good study of *Merulius Lacrymans.*

Maire. He is more a mycologist than a phytopathologist, but he takes great interest in plant pathology. His works in this branch are on the Plasmodiophoraceae and Uredinales. Since he lives in Algeria, he is often consulted on the diseases occurring in that country.

Chifflot. Of the Lyon's Faculty of Sciences, he has published numerous notes on the horticultural and orchard diseases.

Moreau. At Clermont-Ferrand he has studied the hop-diseases. Actually he is interested in genetics of wheat and also in wheat diseases.

We must mention here some cytologist and mycologist who have largely contributed to the development of plant pathology, such as. Dangeard, Sappin-Trouffy, Molliard, Matruchot, Constantin, Noffray, Leme, Perret and Leverin.

I can not finish this account without giving my acknowledgment to M. Etienne Foex, Director of the Paris Plant Pathological Station, who sent me references from his own hand, and to my professor Dr. B. T. Dickson for the suggestions he gave me.

THE LATE NAPOLEON A. COMEAU

By E. T. D. Chambers, Quebec.

By the death, two years ago at Godbout, of the late Napoléon A. Comeau, natural history in Canada has lost one of its oldest and most devoted investigators. His was a remarkable and a most usefullife. He was born more than fourscore years ago at one of the small Hudson Bay posts at Jérémie Island, Hudson Bay, long since abandoned, where his father was the Hudson Bay Company's Agent. Comeau was appointed private guardian of the Godbout salmon river in 1860, and practically resided there up to the time of his death in the autumn of 1923. He had few schooling opportunities, but possessed a consuming desire for knowledge, and was largely a self-educated man. From the book of Nature he learned much, for of other brooks, in his early life, he had but few.

In the autumn of 1882 he was the companion of Baron de la Grange on a hunting trip in the mountains of Wyoming. He was an occasional visitor to Quebec, but was not particularly fond of life beyond the limits of his native Canadian Labrador, though in October 1922, upon the special invitation of the Honorable Honoré Mercier, Minister of Lands and Forests of the Province of Quebec, and the then President of the International Association of Game,

Fish and Conservation Commissioners, he attended the annual convention of the Association held at Madison, Wisconsin, to read a paper on the Wild Life of the Canadian Labrador, with special reference to the birds of that coast. Upon that occasion, he received quite an ovation, all those present crowding around him eager lest they should lose a word of what he had to say to them, and Mr. F. G. Walcott, of Norfolk, Conn., rose immedialtely after Mr. Comeau had spoken, and offered a resolution to—"express gratitude for Mr. Comeau's coming this long distance so that we might not only hear him but see him. I want to say just this word", he continued; "about ten years ago when Frederic Selous came over to hunt in Newfoundland, he stopped with me on his way back just before he sailed, and said he had found a marvellous man up there in the person of Mr. Comeau who knew the natural history of his country as few men did, and had the gift of telling it. A little later, I read that book, "Life and Sport on the North Shore". I immediately bought fifteen or eighteen copies and sent them to friends of mine. Sheldon and Chapman and myself all had the marvellous privilege of being with Warburton Pike at one time or another; and Warburton Pike got this book, looking upon it as a classic. So in offering our thanks to Mr. Comeau, I personally appreciate more than I can tell you the privilege of looking at his face and hearing him talk."

For years and years he was the only man with any knowledge of medecine along a coastline of many hundred miles. In the families of the scattered residents in the various fishing settlements along the coast, "the stork" invoked Mr. Comeau's assistance over 230 times, and without a single fatality. The surgical skill which he had acquired by years of practice, following a hospital course of only one month, the medical knowledge which was his by virtue of the private study and reading of a lifetime, his surgical instruments, dental and other forceps, stock of drugs and the diphtheria and other serum supplied by the Government in times of epidemic, were always freely at the disposal, not only of the people of his immediate territory, but also of all those whom be could claim as neighborus for hundreds of miles around.

This sketch cannot be made long enough to contain a reference to all of Mr. Comeau's many activities. At Godbout, where he resided he was postmaster, telegrapher, deputy-coroner, Dominion Government fishery overseer, guardian of the salmon fishing. He has served as agent for the Hudson Bay Company, and spoke the language of the Montagnais Indians as well as he did English and French. Having practically lived all his life upon the coast, his knowledge of many tragic scenes and incidents was acquired at first hand, and described in his book "Life and Sport on the North Shore" in the native simplicity of language and manner characteristic of the author.

Special urging was necessary to induce Mr. Comeau to tell of his heroic crossing of the Lower St. Lawrence, with his brother, in an open canoe in midwinter, through forty miles of ice, exposed to a temperature of many degrees below zero, for two days and a night, in the successful effort to save the lives of two of his friends. Only for the purpose of correcting earlier and erreneous reports

of this dramatic event, did Mr. Comeau consent to tell it, as he done in the chapters of his book modestly entitled "Across the St. Lawrence" and "Our Return Journey"; notwithstanding that all the newspapers in Canada and the United States sounded the praises of the rescuers, and that the Governor-General, the Lieut.-Governor, the Royal-Humane society, the Government of the Dominion, and the Société des Chevaliers Sauveteurs des Alpes Maritimes of Nice, vied with each other in showering honors upon them.

To the cause of science, Mr. Comeau has rendered signal service. His text-book has been that of Nature. Other works of which his library at Godbout contains a useful selection and occasional visits to museums, have aided him in his studies of comparative anatomy. In original research he has done much good work for which he has received the thanks of officials of the Smithsonian Institution and members of various learned societies. His list of the birds of the North Shore, published in his book, is a scientific work of permanent value,

The chapters devoted to the natural history of the North Shore, and especially to trapping and salmon fishing, are the work of an expert, and there is scarcely an angler anywhere who will not be interested in Mr. Comeau's description of the salmon rivers of the North Shore, and of the various salmon problems out of the fullness of a life-long experience. What salmon fisherman will not be attracted by the scores faithfully preserved for the last fifty years of the salmon killed by rod and line in the Godbout River, and by the extra-ordinary kill of 57 salmon in one day, to Mr. Comeau's own rod, on the 9th July 1874?

The life story of the trapper and the folk-lore of the Indian hunters of the North Shore are contributions to our national literature that are destined to live, and not the least charm of Mr. Comeau's volume lies in the fact that it is a sane and instructive book, conveying a graphic yet modest recital of fifty years' work for humanity and science in one of the least known but most interesting sections of Northern Canada.

NOTES ON THE MOSQUITO FAUNA OF QUEBEC.

By C. R. Twinn, Entomological Branch, Department of Agriculture, Ottawa.

Mosquitoes are small, slender two-winged insects, with the veins and hind margins of the wings bearing scales. They belong to the order Diptera, family Culicidae, of which, two sub-families, the sub-family *Culicinae*, of true biting mosquitoes, and the sub-family *Chaoborinae* of non-biting mosquitoes, are dealt with in this paper.

Although mosquitoes undoutedly play an important part, during the summer months, in the lives of the people of Quebec, their study has been surprisingly neglected in the past, and few published Quebec records are available. Winn and Beaulieu (6), in 1915, recorded the following twelve species in the province: *Anopheles punctipennis* Say, *Aedes canadensis* Theo., *A. cantans* Mgn., *A. cinereoborealis* F. & Y., *A. consobrinus* Rob. Desr., *A. dyari* Coq., *A. pagetonotum* D. & K., *A. pullatus* Coq., *A. subcutans* Felt, *A. sylvestris* Theo., *Culex pipiens* L., and *Sayomia punctipennis* Say. Of these *Aedes cantans* is now known as *A. maculatus* Mgn., and according to Edwards (3), in his "Revision of the Mosquitoes of the Palaeartic Region", is apparently confined to Europe. *Aedes dyari, Aedes sylvestris* and *Sayomia punctipennis* become *Theobaldia dyari, Aedes vexans* and *Chaoborus punctipennis* respectively, *Aedes consobrinus* probably refers to *Culex pipiens* L., and *Aedes subcutans* to *A. stimulans* Walker. The occurrence of *Aedes pullatus* in Quebec seems doubtful as this species is western in its distribution, and has elsewhere been recorded only from Western Canada and the Western United States.

Dyar (1) in his "Mosquitoes of Canada", records only two species of mosquitoes from Quebec, *Aedes intrudens* Dyar and *A.* (*trichurus*) *cinereoborealis* F. & Y. In the following pages I have listed twenty-four species as occurring in the province, the majority being here recorded for the first time. Eight genera are represented of which six, namely, *Aedes, Culex, Anopheles, Taeniorhynchus, Theobaldia* and *Psorophora* belong to the sub-family *Culicinae* and are characterised by a long proboscis and normally scaled wings; and two, *Corethra* and *Chaoborus*, belong to the sub-family *Chaoborinae* the members of which have a short proboscis and hair-like scales on the wings.

SUBFAMILY CULICINAE

Genus Aedes Meigen

Of the foregoing genera, the genus *Aedes* is by far the most important as it includes the most abundant, widespread and troublesome species of the Canadian fauna.. Mosquitoes of this genus frequently make life almost intolerable in the Quebec woods, during spring and early summer, and harass the inhabitants of cities, towns and hamlets wherever conditions are favorable. They may be distinguished from the mosquitoes of other genera by the arrangement

of the thoracic bristles: i. e., by the presence of a row of proepimeral bristles and a group of post-spiracular bristles, and the absence of spiracular bristles.

The larvae develop almost exclusively in temporary bodies of water such as snow and rain pools, and flooded areas inundated by the spring river freshets. The eggs which are laid on water or in damp situations during the summer months carry the species through the winter, and hatch when submerged in the first warm days of early spring. * As the eggs are not all submerged at the same time owing to fluctuations in precipitation and other climatic conditions, the adults may continue to emerge over a considerable period, proving troublesome as late as the end of July, and persisting in small numbers into the autumn. They are usually most annoying, however, in late May and June. The larvae feed upon small aquatic organisms such as algae, and on the soft tissues of decaying leaves. Leafy-bottomed woodland pools may frequently be found teeming with the larvae. All of the Quebec species of *Aedes* are persistent and troublesome biters, and although the majority of them are most active at dusk, they will bite viciously in the daytime, whenever occasion offers.

* It is considered probable that the eggs of at least some species of *Aedes* will hatch after remaining unsubmerged on the ground for several years.

Thirteen species of this genus have been taken in the province, and a brief description and the known distribution of each is given in the following pages.

Aedes hirsuteron Theobald.

This is a small dark-coloured mosquito with black tarsi. The abdomen bears basal segmental white bands, and the mesonotum is marked with a median brown stripe and is creamy yellow at the sides. The larvae were found developing in great numbers at Gatineau Point, in low wooded areas flooded in spring by the Ottawa river. The female is a troublesome biter and will migrate short distances in search of blood.

Quebec Records:

Kingsmere, June 23, 1912 (C. G. Hewitt).
Aylmer, June 13, 1919 (C. B. Hutchings).
Gatineau Point, May-June, 1924 (C. R. Twinn).
Kirks Ferry, July 1, 1925 (C. R. Twinn).

Aedes cinereoborealis Felt & Young.

A large, dark-grayish mosquito, with unbanded tarsi, abdomen with white basal segmental bands and the mesonotum grayish with a median brown band. The larvae may be found abundantly in shallow leafy woodland pools in early spring associated with *Aedes stimulans*. It is one of the earliest mosquitoes to appear and is rather conspicuous owing to its size. It does not appear to be very troublesome and becomes scarce by the latter part of June.

Quebec Records:

Chelsea, May 17, 1902 (Arthur Gibson).
Cottage Beaulieu, (Rigaud), June 29, 1904 (G. Beaulieu).
Aylmer, May 24, 1919 (C. B. Hutchings).
Kippewa, June 1924 (M. B. Dunn).
Hemmingford, May 26, 1925. (G. H. Hammond).
Kirks Ferry, June 28, 1925 (H. L. Viereck).

Aedes intrudens Dyar.

This medium sized dark-coloured mosquito develops in shallow, leafy woodland pools in early spring. The tarsi are dark-scaled and the mesonotum is bronzy-brown. Dyar (1) states that this is the only forest species which has the habit of entering houses.

Quebec Records:
Chats Rapids, May 24, 1900 (J. Fletcher).
Ironsides. May 23, 1908 (Arthur Gibson).
Aylmer, May 23, 1919 (C. B. Hutchings).
Hemmingford, May 19, 1925 (G. H. Hammond).

Aedes lazarensis Felt & Young

A dark, moderately large mosquito, with the mesonotum varying in colour from brownish or grayish to yellow, and bearing two longitudinal, median, dark-brown stripes, separated by a narrow pale stripe. The tarsi are black and the abdominal segments banded at the base with white scales.

Quebec Records:
Ironsides, May 23, 1908 (Arthur Gibson).
Chelsea, May 30, 1908 (J. A. Letourneau).
Aylmer, June 6, 1919 (C. B. Hutchings).

Aedes impiger Walker.

This species is smaller than *A. lazarensis* but closely resembles it in body markings. The larvae are also similar. The adult can be separated from A. *lazarensis* by its general appearance and by a careful study of the male genitalia.

Quebec Records:
Chelsea, June 5, 1919 (Arthur Gibson).

Aedes punctor Kirby.

A moderately large, dark-coloured mosquito with black tarsi, and white basal segmental bands on the abdomen. The markings of the mesonotum vary somewhat, but the latter is usually golden at the sides and bears a broad dark-brown median band. It is said to be a bad biter, but it does not appear to be abundant in Quebec.

Quebec Records:
Chelsea, May 50, 1908 (Arthur Gibson).
Aylmer. May 25, 1925 (C. H. Curran).

Aedes cinereus Meigen.

This is a small, dark-coloured species, with black tarsi and dark-brown mesonotum. The narrow, white, basal segmental bands of the abdomen, broaden out at the sides forming a more or less continuous lateral white line. Although small this mosquito inflicts a painful bite. It is chiefly an inhabitant of the

woodland and has not been taken in any great numbers. Larvae were collected in association with other species of *Aedes* in open woodland, flooded by the Ottawa river at Gatineau Point, in early May, 1924.

Quebec Records:

Gatineau Point, larvae May 5, 1924; adults May 26—June 6 (C. R. Twinn).
Notre Dame de Grace,Montréal, June 21, 1925, (W. St. G. Ryan).
Aylmer, June 24, 1925 (C. E. Yauch).
Kirks Ferry, July 1, 1925 (C. R. Twinn).

Aedes triseriatus Say.

A medium-seized blackish mosquito, with the mesonotum dark-brown centrally, and silvery scaled at the sides. The abdomen is marked laterally with triangular white patches at the base of each segment, and the legs are black and without tarsal segmental rings. The larva closely resembles that of the yellow fever mosquito, *Aedes aegypti* Linn., which, however, has not been taken in Canada. The larvae develop in tree-holes and artificial receptacles. It is comparatively rare in Quebec.

Quebec Records:

Kingsmere, June 23, 1912, (C. G. Hewitt).
Aylmer, Sept. 16, 1925 (C. E. Yauch).

Aedes stimulans Walker.

This is a common mosquito in Quebec and a bad biter. It will bite freely during the daytime as well as at dusk. It is moderately large, and the tarsal segments are broadly banded at the base with white scales. The thorax is ornamented by a broad reddish-brown band, and the abdomen bears distinct white, basal, segmental bands. It can be separated from A. *fitchii* and *A. excrucians* only by a study of the male genitalia or the larvae. I have taken it in considerable numbers at Gatineau Point, on Nun's Island (Montreal), and at Norway Bay. It persists well into the summer.

Quebec Records:

Cottage Beaulieu (Rigaud), Aug. 16, 1906 (G. Beaulieu).
Aylmer, May 27, 1919 (J. McDounnough).
Gatineau Point, Larvae, May 5, 1924; adults, May 24—June 4, 1924 (C. R. Twinn).
Nun's Island (Montreal) June 3, 1925 (C. R. Twinn).
Norway Bay, July 25, 1925 (C. R. Twinn).

Aedes fitchii Felt & Young.

This species is closely allied to *A. stimulans*. It is probably quite common in Quebec, but few definite records are available, possibly owing to the difficulty of distinguishing the adult female from that of *A. stimulans*. At Ottawa it occurs quite commonly, the larvae being frequently associated with those of *A. stimulans* and *A. excrucians*.

Quebec Records:

Aylmer, May 27, 1919 (J. McDunnough).
Doubtful records (♀ ♀ only; possibly *stimulans*) follow:
Hemmingford, June 25, 1916 (C. E. Petch).
Aylmer, June 14, 1925 (H. L. Viereck).
Montreal, June 23, 1925 (W. St. G. Ryan).
Maniwaki, June 25, 1925 (C. H. Curran).

Aedes vexans Meigen.

A rather small, brownish mosquito, with the tarsal segments ringed with narrow white lines at the base. The mesonotum is brown, and the basal, white, segmental bands of the abdomen are notched on the dorsal line. Well-grown larvae were taken in moderate numbers in temporary bodies of water at Gatineau Point, early in May.

Quebec Records:

St. Hilaire, July,—; Montreal, June, —(G. Beaulieu).
Gatineau Point, larvae, May 5, 1926; adults May 30—June 11, 1924 (C. R. Twinn).
Hemmingford, July 15, 1925, (A. D. Baker).
Rougemont, August 12, 1925 (G. H. Hammond).

Aedes canadensis Theobald.

This species is one of the most widespread and troublesome mosquitoes of the Quebec woodlands, It is of medium size and can be readily identified by the conspicuous white rings on the base and apex of the tarsal segments, the uniformly dark-coloured scales of the wings, and the reddish-brown mesonotum. There is only one generation, but the adults may be taken throughout the summer until late September, as the overwintering eggs hatch with successive floodings of infested temporary pools. The females are persistent biters, frequently biting during the daytime, particularly in dull humid weather. They were found to be troublesome about summer cottages at Norway Bay, in July and August. Many specimens taken had small red mites attached to the base of the legs.

Quebec Records:

Cottage Beaulieu (Rigaud) July 16, 1906 (G. Beaulieu).
Ironsides, May 25, 1908 (Arthur Gibson).
East Bolton, July 23, 1911 (A. F. Winn).
Chelsea, July 2, 1912 (Arthur Gibson).
Kippewa,(larvae), May 25, 1925 (M. B. Dunn).
Aylmer, June 18, 1925 (C. E. Petch).
Kirks Ferry, June 23, 1925 (H. L. Viereck).
Norway Bay, July 25, 1925 (C. R. Twinn).
Franklin Centre, Aug. 8, 1925 (C. B. Hutchings).

Aedes dorsalis Meigen.

Aedes dorsalis appears to be rare in Quebec. It normally inhabits open country, breeding in freshwater ground pools and also in salt-marshes. It is a

rather small species, yellowish gray in colour, with the tarsal joints ringed with white at the base and apex. The scales of the wings are of two colours, black and white, intermixed.

Quebec Records:

Notre Dame de Grace (Montreal), 1+, June 6, 1925 (C. R. Twinn).

Genus Culex Linnaeus

Culex is the genus next in importance to *Aedes*, in Quebec, although only three species are represented in the province, and of these, two only, are occasionally troublesome. The habits of these mosquitoes differ markedly from the *Aedes*. The winter is passed in the adult stage in protected situations, the larvae developing during the summer months in more or less permanent bodies of water, and in artificial receptacles. Several generations may succeed one another under favorable conditions, all stages from the egg to the adult frequently being present at the same time. In this genus the spiracular and post-spiracular bristles of the thorax are absent and there is usually only one lower mesoepimeral bristle.

Culex pipiens Linnaeus.

This is a rather drab, medium sized species with the vestiture of the mesonotum reddish-brown. The abdomen bears basal, white, segmental bands, the band at the base of the second segment being triangularly produced at the middle. This species is not a native of Canada having been introduced on ships from Europe. It is well established in Ontario and Quebec, but according to Hearle (5) it has only recently gained a footing in British Columbia, a few specimens having been taken at Vancouver. It has not been reported elsewhere in the Dominion, but probably occurs in the Maritime Provinces. It will develop in fresh or polluted water but appears to favour the latter. It often breeds in artificial receptacles and is seldom found far from human habitations. It is this mosquito that causes the residents of Notre Dame de Grace (Montreal) a great deal of annoyance during the summer months, as it breeds in great numbers in a permanent body of somewhat foul water lying between the tracks of the Canadian National Railway, and the high ground on which this section of the city is situated. Fyles (4), in 1907, stated that *Culex consobrinus* Rob. Des., (i. e. *C. pipiens* L.) is the common mosquito at Quebec city. It persist until late in the season.

Quebec Records:

Quebec, 1907 (?) (T. W. Fyles).
Aylmer, Sept. 28, 1924 (C. H. Curran).
Notre Dame de Grace (Montreal) larvae, pupae and adults, Aug. 5, 1925 (W. St. G. Ryan)

Culex territans Walker.

This species resembles *C. pipiens* in general appearance and habits, but the adult may be separated from the latter by the absence of a triangular extension of the central portion of the white basal band of the second abdominal segment. It breeds in artificial receptacles, but appears to favour cleaner water than

C. pipiens. It was found breeding in considerable numbers associated with *Culex testaceus* v. d. Wulp, in a water-barrel containing clean water, under the eaves of a summer cottage, in open woods at Norway Bay. Although much collecting was done, both during the daytime and at dusk, no mosquitoes of this species were taken attempting to bite.

Quebec Records:

Cottage Beaulieu (Rigaud), August 21, 1906;
Dec., 1906 (in cellar) (G. Beaulieu).
Norway Bay, larvae, July 25, 1925; all stages,
August 15, 1925 (C. R. Twinn).

Culex testaceus van der Wulp.

A small blackish mosquito, the distinguishing feature of which, is the presence of transverse apical white bands on the abdominal segments. No specimens were taken attempting to bite, in the vicinity of its breeding place at Norway Bay, and Dyar (1, p. 76) states that it does not attack warm-blooded animals. Larvae were found in moderate numbers in a clean water-barrel at Norway Bay, in July and August. There appear to be no other records of this species in Quebec.

Quebec Records:

Norway Bay (larvae), August 16, 1925 (C. R. Twinn).

Genus Anopheles Meigen

There are two species of *Anopheles* in Quebec, but both are comparatively rare. The adults of this genus may be readily distinguished from those of other genera by the fact that the scutellum is rounded, not trilobed, and the palpi are long in both sexes. The wings of the Quebec species are spotted. Anophelines overwinter in the adult stage in sheltered situations such as the cellars of houses The larvae are surface feeders and develop in a variety of situations.

Anopheles punctipennis Say.

A moderately large species with the wings black scaled, with the exception of large yellowish-white spots on the anterior margins. A female specimen gorged with human blood was taken on a woodland road at Norway Bay at 9 a.m., on a dull humid day in July. This species is well-known in other parts of the world as a dangerous carrier of malaria.

Quebec Records:

Montreal, November, — (A. F. Winn).
Hemmingford, —, 1922 (C. E. Petch).
Norway Bay, July 25, 1925 (C. R. Twinn).

Anopheles maculipennis Meigen

This species is closely allied to *A. punctipennis* but may be easily separated from it by the presence of four black spots on the wing, and a coppery fringe of scales at the wing apex. This mosquito is also known to be a carrier of malaria. As in the case of *A. punctipennis* it is fortunately rather rare in the province.

One female was taken in a cottage bedroom at Norway Bay by lamplight, in August, and two females on the verandah of a summer cottage, at Gatineau Point in April. In both cases they appeared to be searching for a meal of blood.

Quebec Records:
Gatineau Point, April, 23, 1925 (C. R. Twinn).
Norway Bay, August 11, 1925 (C. R. Twinn).

Genus Taeniorhynchus Arrib.

This genus is represented by one species only in Quebec. The generic distinction, based on the thoracic bristles, is the absence of spiracular and post-spiracular bristles, and the presence of a row of proepimeral bristles and a group of three or four lower mesoepimeral bristles. The recorded larval habits of *Taeniorhynchus* are remarkable, the larva remaining below the surface of the water throughout its life and securing air by piercing the vascular system of aquatic plants with its modified breathing tube.

Taeniorhynchus perturbans Walker.

A moderately large, pale-brown, mosquito with conspicuously banded legs. A broad pale band is present beyond the middle of the hind tibia, and another at the middle of the first joint of the hind tarsus. The scales of the wings which are very broad, are of two colours, black and white intermixed ,the former predominating. This species develops in marshes and the reedy edges of ponds, and is said to pass the winter in the larval stage. The female is a persistent and vicious biter and frequently enters dwellings. It is not abundant in Quebec.

Quebec Records:
Notre Dame de Grace (Montreal) June 21, 1925 (W. St. G. Ryan).
Norway Bay, July 25, 1925 (C. R. Twinn).

Two other species of *Culicinae*, *Theobaldia dyari* Coq., and *Psorophora discrucians* Walker (a southern tropical species), have been taken in Quebec, but as they are very rare, and of no economic significance, they will not be further discussed here.

Quebec Records:
Theobaldia dyari Coq.
Montreal, May, — (G. Beaulieu).
Psorophora discrucians Walker.
Hemmingford, July 2, 1922 (C. E. Petch).

Subfamily Chaoborinae

The remaining Quebec species belong to the sub-family *Chaoborinae* and are characterised by a short proboscis and hair-like scales on the wings. Two genera are represented in the province, *Corethra and Chaoborus*. They are easily separated, the former being characterized by a very short basitarsal joint, which is much shorter than the second joint. The study of this sub-family has been largely neglected in the past, but Dyar and Shannon (2) have recently given an excellent account of the North American species.

Corethra cinctipes Coquillett.

This species is medium sized, and yellowish-brown in colour, with dark spots on the wings and conspicuously banded legs. At Gatineau Point, in the low wooded areas flooded in spring by the Ottawa river, the larvae of this species abound in the same pools inhabited by larvae of *Aedes stimulans* and *Aedes hirsuteron*. They are predacious in habit and were found to feed upon *Aedes* larvae and also on one another. They are semi-transparent and possess a pair of air sacs posteriorly in the abdomen and another pair in the enlarged thorax. The adults which emerge in May and early June, do not bite.

Quebec Records:
Gatineau Point. larvae, May 5, 1924; adults, June 4, 1924 (C. R. Twinn).

Corethra culiciformis DeGeer.

A medium sized, brown to yellowish mosquito, with pale-yellow wing scales and unbanded legs. Only a few larvae were taken at Gatineau Point and adults were reared from these. Its habits are probably similar to those off *C. cinctipes* Coq.

Quebec Records:
Gatineau Point, larvae, May 5, 1926: adults, June 8, 1924 (C. R. Twinn).
Aylmer, 10 males, June 4, 1924 (C. H. Curran).

Chaoborus punctipennis Say.

A small, delicate, greyish-yellow species with numerous dark spots on the wings and legs, and the basitarsal joint longer than the following joint. The majority of the specimens in the National Collection are males, probably taken while swarming.

Quebec Records:
East Bolton, July,—(A. F. Winn).
Kingsmere, July 18, 1919 (R. H. Chrystal.)
Aylmer, July 25, 1924 (C. H. Curran).

List of references

1. Dyar, H. G. "The Mosquitoes of Canada".
Trans. Roy. Can. Inst. Vol. XIII, Pt. I, 1921, pp. 71-120.
2. Dyar, H. G. and Raymond C. Shannon. "The American Chaoborinae".
Ins. Ins. Mens. Vol. XII, 1924, pp. 201-216.
3. Edwards, F. W. "A Revision of the Mosquitoes of the Palaearctic Region".
Bull. Ent. Res. Vol. 12, 1922, p. 304.
4. Fyles, T. W. Ann. Rep. Ent. Soc. of Ont. 1907, p. 107.
5. Hearle, E. Proc. Ent. Soc. of B. C. Nos. 13-15, 1921, p. 134.
6. Winn. A. F. and G. Beaulieu. "A Preliminary List of the Insects of the Province of Quebec, Part II—Diptera". 1915, pp. 117-118.

COLEOPHORA PRUNIELLA CLEMENS; A NEW PEST OF APPLE IN QUEBEC

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The apple orchards situated close to Lake St. Louis have been heavily infested with case-bearers (Coleophora) for several years past. Other than casual observations, no attention was paid to the situation until 1925, when an attempt was made to control the infestation and a study of the species was started. Early in the work, it was observed that the majority of the cases were strikingly different to those of *Coleophora fletcherella* Fern., (Cigar Case-bearer) and *C. malivorella* Ril. (Pistol Case bearer). Moths were reared and together with the cases they were sent to the Entomological Branch, Ottawa. They were transferred to Mr. C. Heinrich., U. S. National Museum, who identified them as *Coleophora pruniella* Clemens.

The literature in the library of the Entomological Branch, Ottawa, has been examined and resulted in the eight references cited in the bibliography appended to this paper. Clemens (1) gives the following meagre description: "The larva mines the leaves of wild cherry early in October, when it is more than half grown. The case is flattened, having a notch on the upper edge about one-third from the mouth whence it is curved regularly to the hinder end and the under edge is nearly straight from the mouth to about one-third of the length from the hinder-end, where it is deeply notched and curved towards the upper edge thus forming a tail-like appendage. On the upper edge, from the mouth of the case to the anterior notch, the edge is regularly curved."

Clemens (2) repeats what has just been quoted and Zeller (3) adds nothing to the knowledge of the insect. Packard (4) quotes what Clemens (1) had written. Dyar (5) cites this insect in his list. Walsingham (6) indentifies specimens as *pruniella* Clemens but Miss Braun found them to be *demisella* Braun. Braun (7) described the adult quite fully and the case formations briefly. The antennal differences of three common species are given:—

C. cerasivorella—gray antennae annulate with white.

C. pruniella—black and white rings on antennae.

C. fletcherella—antennae not conspicuously annulated.

It is also stated that the other apple and plum species do not resemble *pruniella* closely. Forbes (8) describes the mature larval case, cites Pennsylvania and Ohio for localities and *Prunus serotina* or Wild Black Cherry as the food plant.

Adult—Antennae with basal joint gray slightly thickened with scales, without a tuft, the following 3 or 4 joints are gray, the remainder almost pure white; all are conspicuously annulated with a dark gray, almost black color. Second joint of the palpi whitish with some dark gray scales externally, and with a minute projecting tuft; third joint dark gray. Head whitish gray.

Thorax and forewings gray, sometimes brownish tinged, the scales somewhat darker at the tips. Cilia concolorous. Hindwings and cilia almost concolorous with the fore wings. Abdomen gray, with yellow anal tuft in the male. Fore and middle legs in large part fuscous, with the tips of the joints white; hind legs white, tibiae clothed above with long fuscous hairs, tarsi externally dusted with fuscous.

Expanse 12.5 to 13 mm.

Description from 2 females and 1 male bred from *Prunus serotina* (7).

The moths began emerging on July 7 and continued until August 7, but maximum emergence occurred on July 13. The average length of life for both sexes was approximately 10 days. Mated pairs laid an average of 28.16 eggs but there was a range of from 1 to 94 between the individuals and the maximum laying female also oviposited 49 eggs in one day. The length of time before oviposition started, varied widely being from a minimum of 1 to a maximum of 15 days and likewise the duration of oviposition occupied from 1 to 14 days per individual.

Egg—The eggs are scarcely visible to the naked eye, yet if one is acquainted with their usual situations they are readily seen. The egg when laid is pale yellow and remains so until one or two days before hatching when it is dull yellow. This color variation is a good indication of the age of the egg. The egg is circular in outline gradually narrowing from the base to the apex, and resembles a miniature inverted jelly-mould. The base is flat and fastened firmly to the leaf. There are from 12 to 16 raised areas or ribs running from a small circular area at the apex to the base. These ribs differ in size and shape (Fig. 1). At the approach of hatching, if the egg is examined under a hand lens the young larva is plainly visible. The head is situated towards the margin of the egg and next to the leaf. The egg stage varied from 16 to 20 days and the average was 18 days.

Larva.—The larva bores through the egg shell and then into the leaf tissue, making a hole directly beneath where the head of the embryo rested and between the upper and lower leaf surfaces. Feeding commences at once and the excreta is stored in the egg shell. The egg serves as a case for the larva until it is completely filled with frass. The larva gradually bores its way into the leaf tissue and forms a mine around the old egg shell.

The larvae first appeared on July 30 and feeding started with their appearance. Feeding continued until October 12, when all the case-bearers had passed from the leaves to the twigs, where they spend the winter. Migration from the wintering quarters to the opening buds started May 8 and was practically completed by May 18. Feeding was mostly done on the under surface of the leaves. After the second addition had been made to the case, feeding ceased for a short period and most of the larvae migrated to the petioles and small twigs close to the injured leaves. Later a third addition to the case was made but by June 21 feeding was almost finished and ninety-six per cent of the larvae had pupated. In a few instances the larvae were found feeding

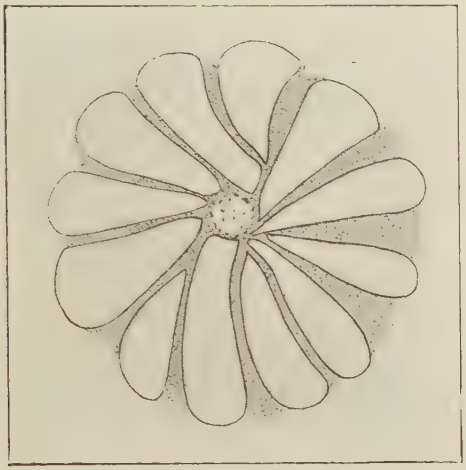

Fig. 1.—Egg of C. pruniella magnified several times. (Original T. Armstrong).

Fig. 2.—Larval cases of C. pruniella.

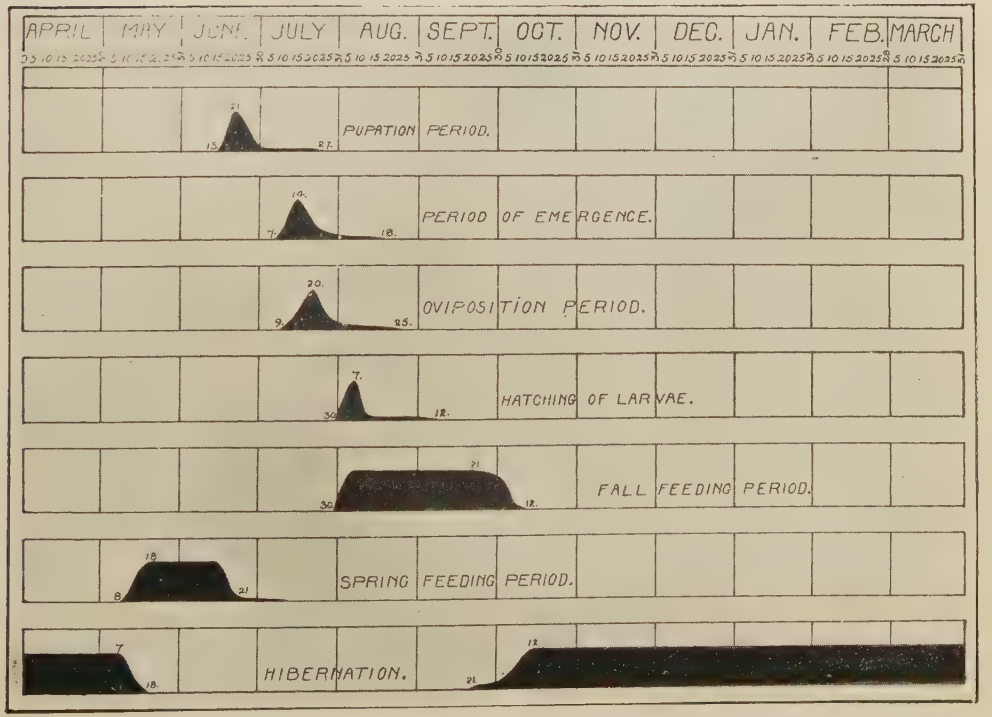

Fig. 3.—Life history graph of C. pruniella. (Original by T. Armstrong).

Fig. 4.—Foliage injury due to larval feeding and case-making of C. pruniella (Original)

on the sepals and later some fed on the young apples but the major portion fed upon the foliage.

Case.—As the common name implies the larval life is spent in a case manufactured from leaf tissue and silk spun by the larva. The first case is made from the upper and lower leaf surface tissue and formed into an oval shaped enclosure. It is constructed from 5 to 10 millimeters from the old egg shell and when the case is completed the larva migrates and attaches itself to the leaf. When one area is mined out it passes to a new location and invariably the new site is closer to the edge of the leaf. On September 9, nearly all the young case-bearers were near the edge of the leaves. After feeding for about two weeks an addition is made to the primary case, which is cut from the edge of the leaf. In this stage, the insect passes the winter. In the spring, three additions are made to the case. All the sections are clearly defined except the primary case. This is either lost or fused, so that the line of demarcation, so prominent in the fall, has disappeared at maturity. The mature case is made up of sections each joined to its neighbour in such a manner as to form a serrated upper edge and the lines of demarkation form an angle of approximately 45° with the lower edge. (figs. 2 and 3).

Host Plants.—The host plant most favoured at Lachine, Que., was the apple. Both early and fall varieties were attacked and immunity in any variety was not observed (fig. 4). *Prunus virginiana* (Choke Cherry) was the second most important host, whereas *Prunus serotina* (Wild Black Cherry) is the only host listed by Clemens (1) (2), Packard (4), Braun (7) and Forbes (8). Slight injury was done to *Crataegus* sp., cultivated plum, cherry and pear.

Artificial Control.—Applications of lead arsenate, calcium arsenate, Commercial Spray Oil, and lime sulphur-calcium arsenate used four times at the regular spraying periods failed to give any satisfactory control.

Natural Control.—The larval and pupal stages are very severely parasitized and this results in lessening the amount of injury very considerably. The following parasites were reared,—*Spilochalcis torvina* Cress., *Microbracon pygmaeus* Prov., *Orthizema areator tenellus* Say, *Erydinota lividicorpus* Gir., *Amblyteles funestus*, *Amblyteles comes* and *Amblyteles subrufus*. There were ten other species indentified as far as the genus.

Bibliography

1. 1861—Clemens,—Proc. Entom. Soc. Phila., i, 79, 1861.
2. 1872—Clemens,—Tineina of North America, 167, 1872.
3. 1873—Zeller,—Verhandlungen zoologisch-botanischen Gesellschaft in Wien. XXIII, 309 873.
4. 1890—Packard, A. S.,—Insects Inj. to Forest and Shade Tress; 5th Rep. U. S. Entom. Comm., Wash., 1890, p. 528.
5. 1902—Dyar,—List North Amer. Lepidoptera, No. 6034, 1902.
6. 1907—Walsingham,—Proc. U. S. N. M., XXXIII, 216, 1907.
7. 1914—Braun, Annette F.,—Cincinnati Soc. Nat. Hist., XXI, No. 4, June, 1914.
8. 1923—Forbes, W. T. M.,—Lepidoptera of New York and Neighboring States; Corn. Univ. Agric. Exp. Sta., Memoir 68 June, 1923, p 209.

HOUSEHOLD INSECTS.

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1.—HOUSEHOLD INSECTS AND PUBLIC HEALTH

It seems unnecessary to point out that there are insects of various sorts which are found habitually in human dwellings. This fact is borne in on us by our daily experience, and week by week the number of inquiries on the control of such insects as flies, bedbugs cockroaches and fleas increases in number. Undoubtedly these creatures work unremittingly to the discomfort of man. But there is another aspect of the question which merits consideration and which it behoves us to pause awhile and consider; namely, what is the influence on public health of this association of man and insects?

It is but a scant fifty years since the scientific world has begun to realize that certain insects transmit to man diseases which are often deadly. The unremitting researches carried out through the co-operation of entomologists, physicians, public health authorities and biologists have brought to light certain valuable and incontrovertible facts regarding this question of insect transmission of disease.

It is well known that epidemics may be caused by parasitic organisms, which transmitted from a diseased to a healthy person, cause in the latter the same pathological symptoms. To quote but one example, the germs of tuberculosis, contained in the dried sputum of a patient may enter with dust into the lungs of a perfectly healthy individual, establish themselves there and set up the disease. But the transmission of disease germs does not always take place directly. Our houses throng with creatures capable of transmitting to the inhabitants, the organisms of infectious diseases.

Do we consider the myriads of flies which invade our dwellings each summer's day to be desirable guests? Indeed it has been proven beyond doubt that these simple domestic flies might carry on their legs millions of germs which they deposit either on our persons or on our foods, thus serving as active agents in the dissemination of such infectious diseases as typhoid fever and infantile diarrhoea.

This method of infection explains in large measure why the infant mortality is so high during the summer months. At this time it is necessary to guard very carefully the health of these frail beings; too often the most elementary principles of hygiene are ignored; milk, the ideal infant food, remains for entire days exposed to torrid heat and to the incursion of disease—carrying flies, and one often sees these defenseless babies covered with flies carrying innumerable germs which they distribute as they crawl from place to place.

Habit, always stronger than reason, causes us generally to consider flies as inoffensive creatures, though rather a nuisance. But a little knowledge teaches

us how absolutely necessary it is that we should protect ourselves from these unwelcome guests. We shall point out later on how to control these insects and thus reduce the dangers to which they subject us.

In the struggle against harmful insects which invade our houses, there are two factors of prime importance,—meticulous cleanliness and perseverence. Cleanliness in the home and personal cleanliness are the essential hygienic precautions, but I wish to emphazise here the need for a persevering and untiring vigilance combined with the most scrupulous cleanliness in dealing with these pests. Perseverence is necessary because while some methods of control will give practically perfect results with one application these methods are usually difficult or dangerous for the layman to employ. The safer insecticides on the other hand need to be applied several times before control is assured. An experience of ten years has shown me that only by persistence in the use of these insecticides can satisfactory results be obtained. Hydrocyanic acid gas is an almost infallible remedy, although some eggs are resistant. Its extreme toxicity to man, however, renders it unsafe for general use and mention is made of it here only to point out that where milder remedies fail recourse can be had to this method of control. It should, however, be used only by professional men capable of using it without danger. In the larger towns and cities the public health department maintains inspectors trained in this type of work.

Following this general review of the insects annoying or dangerous to man, we will deal with the habits of the individual pests and the methods of control.

If the information contained in these pages should aid the readers in reducing the annoyance and danger of these household pests, I will feel that their preparation has not been a fruitless task.

II.—THE PARASITES OF MAN

The insects which attack man directly, or constitute a menace to his health are bed bugs, fleas, flies, lice and their allies.

1. *The bed bug—(Cimex lectularius L.)*

It is thought that the presence of bed bugs in a dwelling is always a sign of uncleanliness. This is a gross error because these insects can enter and establish themselves in the best ordered of households. They are often found in railways, tramways, stations, hotels, restaurants, etc., and hence infect rich and poor alike. The only necessary condition for their installation in dwellings is the presence of human blood on which they feed.

Description and Habits.---The adult is a reddish brown insectwith a flattened body well adapted to squeezing into cracks and narrow spaces in walls, floors, furniture, etc. The size varies, some full grown adults measure only 1-8 inch in length, while others may attain a length of 1-3 inch. Like all Hemiptera the

bed bug is provided with a beak which in this case is short and strong and capable of piercing the human skin. Nocturnal inhabit the bed bug conceals itself during the day in cracks in the walls, behind wall papers and hangings or in the furniture. At night, driven by its instinct for feeding on human blood, it leaves its hiding places and attacks the sleeping host. The bite produces a sharp pricking sensation.

The female lays her eggs in her sleeping places, where they hatch after a varying period depending on the temperature. The young bugs or nymphs become full grown in about three months and feed on human blood like the adults throughout their lives.

Bed bugs are able to resist starvation for six months or longer, hence their persistence in houses that have been unoccupied for months.

Control.—Four types of control measures present a wide choice and an efficiency varying according to the nature of the substance and the care and persistence used in its application.

(1) Liquids: benzene, gasolene, kerosene, boiling water sprayed or injected into the hiding places will destroy large numbers.

(2) Poisons: The most effective is mercuric chloride (corrosive sublimate) which may be used dissolved in plain water, or according to the following formula:

Mercuric chloride	5 gm.
Camphor	12 gm.
Alcohol	700 gm.
Spirits of turpentine	25 gm.

(N. B. The turpentine should not be added until all other ingredients are dissolved).

This preparation may be applied with a brush into the cracks of walls, furniture and any place where the presence of bugs is suspected.

(3) Heat:—Superheating a closed room at a temperature of 125° F. for 4 to 6 hours will destroy the bed bugs.

(4) Gas:—Sulphur dioxide, carbon bisulphide and hydrocyanic acid gae are all effective. Directions for fumigation are given at the end of this articls.

Fleas (*Pulez irritans* L. etc.)

Several species of fleas are found in houses: the human flea (*P. irritans*,) the dog flea (*Ctonoceplalus canis* Curtis) which is usually the commonest form, and the cat flea (*Ct. felis C.*) These all annoy by their bites and are sometimes so numerous as to make residence unbearable.

Description and Habits.—The flea is a minute wingless insect having strong leaping legs. Its body is laterally compressed and provided with backward projecting spines which help it to glide easily through imprisoning fingers. For the most part fleas live as parasites on domestic animals (cats, dogs, rats, mice) from which they pass to man.

The eggs laid by the female on its host fall to the ground in places where such hosts habitually lie. The eggs hatch in 2 to 12 days depending on the favorableness of the environment. The larva is a small worm-like creature which feeds on waste organic matter and does not attack living animals. After feeding for one or several weeks the larva forms a cocoon within which it transforms to the pupa. The final transformation to the adult stage takes place about one week later.

The bite of the flea leaves a sharp burning sensation.

Fleas are most abundant in summer and autumn, declining in numbers in winter and spring. Moisture favours their multiplication so that rainy summers are usually the most favourable flea seasons. In many houses the cellar forms the breeding ground of fleas, because it is here that the domestic animals are usually found. Indeed it has been observed that fleas have a marked preference for dark cellars.

Fleas serve as agents in the dissemination of bubonic plague.

Control.—Knowledge of the habits of fleas suggests several methods of control.

(1) *Removal from domestic animals.*—Dogs should be bathed thoroughly in a solution of 3% creolin for 5 to 10 minutes or with carbolic soap. This treatment not only gets rid of the fleas but disinfects the wounds made by them.

Cats or other delicate-skinned animals should be washed in 2% creolin. Pyrethrum or naphthaline rubbed into the fur from time to time is effective and does not irritate the skin.

(2) *Sticky fly paper.*—We have found that ordinary sticky fly-paper placed in places frequented by fleas will attract and catch the leaping adults.

(3) *Destruction of larvae and eggs.*—We have seen that the larvae live beneath carpets, in the cracks of floors and in the sleeping places of cats and dogs. Lift the carpets, sweep carefully and burn the sweepings which will contain the eggs and larvae. Beat well before replacing carpets, and sprinkle pyrethrum or naphthalene flakes on the floor. Similar treatment is recommended for other haunts of the larvae.

(4) *Exterminate Rats*—which are the principal reservoirs of fleas, by means of mechanical traps, poisons, &c.

Treatment of Bites.

The saliva injected at the time of bitting causes an inflamation of the tissues and a characteristic pain. Some individuals are particularly sensitive and if bitten often in the same region suffer considerably.

The following substances are recommended in such cases:—Three per cent solution of carbolic acid, carbolated vaseline, menthol or camphor. Tincture of iodine alleviates the pain, but its use should be avoided on the skin of young children or persons suffering from eczema for fear of raising blisters.

The House Fly (Musca domestica L) and Related Flies.

Of all household insects the most widely distributed, the most familiar and the most dangerous are without doubt the flies. Not only do they conti-

nually annoy the inhabitants of town and country by their abundance, but they expose them to most serious diseases. It is definitely known that the housefly disseminates the germs of several contagious diseases, germs which it may carry by the millions adhering to the hairs which clothe the body.

The list of diseases known to be disseminated by flies includes typhoid, infantile diarrhoea, tuberculosis, septicaemia, anthrax, trachhoma. Because of its habits the fly is eminently fitted to transport disease germs. The larval stage is passed in ordure or other decaying organic matter and to such places the adult returns to lay her eggs. The fly becomes contaminated with the germs which grow abundantly here and usually flies directly to some dwelling where the germs are transferred to the food over which the insect is too often allowed to crawl.

The defenceless babies are the most exposed to fly-borne infection. Often through parental negligence the milk on which these infants feed is not protected from flies. If a typhoid-carrying fly falls in such milk, the offending insect is removed but numerous germs are left in the milk and may bring about a fatal infection in the consumer.

Description and Habits.—The two-winged housefly with densely pubescent body is too well known to need any description here. We may note in passing that several species of flies are commonly found in houses Eg. *Musca domestica*, *Lucilia caesar L.*, *Homalomyia caniculans L.*; biting flies from neighbouring stables such as *Stomaxys calcitrans* and sometimes the small fruit, fly, *Drosophila ampelophila* Loew which is attracted by decaying or fermenting fruit. These flies all have similar habits and expose us to the same dangers.

The female lays its eggs in fresh dung, kitchen refuse, animal or human excrement, preferably in moist or fermenting material. Each fly lays 100 to 150 eggs at a time. In warm weather the white cylindrical larvae hatch in twenty-four hours. With the extreme heat of our summers these larvae develop in about five days, then transform into a brown puparium from which the adult emerges in about three days. The housefly multiplies so rapidly that if all the offspring and descendants of a single pair survived from spring to autumn the number in the autumn would be approximately six sextillions.

In the autumn reproduction ceases and a few flies hibernate to perpetuate the species in the following spring.

It must be borne in mind that those towns and villages whose sanitation is properly looked after, i.e., those kept free of manure, vegetable rubbish etc. are relatively free from flies. On the other hand a single mannure heap left untreated will serve for the breeding of thousands of flies, sufficient to infest the entire locality. The fight against flies must be directed mainly to the prevention of such accumulations.

Control.

The simplest and surest means of control is the prevention of breeding by treatment of their breeding places. The methods described below are preventive

and curative and our experience in several towns has shown that if persistently applied, these methods will reduce the fly plague to an insignificant factors.

(1) *Treatment of the breeding places.*—One should nowhere allow manure or any other type of putrifactive organic refuse to accumulate in the neighbourhood of dwellings. In towns each stable should be furnished with a manure box, hermetically sealed and communicating with the stables by a well fitting door of wood or wire netting. The manure should be stored in the box daily and spread once a week in the fields at least half a mile from the houses.

In the country advantage may be taken of the fact that maggots will not live in dry places. A platform of spaced wooden slats is constructed above a cement tank. The manure is placed daily on the platform, the liquid drains through to the tank where it is retained so that the valuable plant food in it can be utilized. The larvae seeking moisture in the bottom of the pile fall through into the tank and are killed. The manure should be removed once a week and spread immediately.

If the manure is piled in the open air on the ground, it should be treated twice a week with chloride of lime or with kerosene emulsion (1 in 10). Borax applied to the pile at the rate of ½ lb. per 8 bushels will kill most of the larvae. After applying the borax the pile should be well wetted in order that the borax should penetrate thoroughly.

If manure is stored in any considerable amount the pile should be at least ½ mile away from the nearest dwelling.

(2) *Treatment of refuse.*—Flies multiply readily in garbage. All kitchen refuse therefore should be stored in cans having well fitting covers and later burned or buried. If necessary garbage should be treated with chloride of lime or borax as described above.

(3) *Control in houses.*—If the inhabitants of every village or town would adopt the methods given above, very few flies would ever be found in houses, but it will be some time before these methods become general, and in the meantime we must use palliative measures to keep out or to exterminate flies from houses.

(a) Furnish doors and windows with wire mesh or mosquito netting screens

(*b*) Keep flies away from pantries or wherever food is stored.

(*c*) Cover all foods, milk, etc., with cheese cloth or wire netting covers.

(*d*) Use sticky fly paper.

(*e*) Protect infants by covering cradles, etc., with muslin or mosquito netting.

(*f*) Do not allow a single fly in sick chambers, especially if the patient is suffering from an infectious diseases.

(*g*) Disinfect all sputum of consumptives as flies will take up tuberculosis germs from sputum.

(*h*) Flies may be driven from a room by lowering the blinds, opening the outer door and burning pyrethrum powder over a lamp or evaporating a tea spoonful of carbolic acid on a hot surface.

(*i*) Formalin bait—Mix a tablespoonful of formalin with half a pint of milk and water mixed in equal parts. The mixture is placed in a deep plate and a small piece of bread added. The flies are attracted to the bait and poisoned by the formalin. The dead flies should be swept up and burnt. Formalin may be purchased from the druggist for about 40c the half pint.

(*j*) Municipal authorities should pay attention to this important question, laws should be made to enforce the proper treatment of all sources of larval food and the proper sanitation of stables, streets, dairies, etc. Any expenditure to this end tends to promote the well being of the population and to ameliorate the conditions of life by removing the sources of infection.

Lice (*Pediculis capitis* DeGeer, and others).

These parasites live on man and other animals and pass readily from one individual to another. Children often become infested through contact with other children.

The species found on man are the body louse (Pediculus).

Description and Habits.—The insects are small and wingless. They have a sucking beak and strong clasping legs by means of which they attach themselves to the hairs of the body or head. The commonest form is the head louse, which lives among the hair of the head, sucking blood from the skin at the base of the hairs.

The eggs are glued to the hairs to which they stick fast. These are commonly known as "nits". They hatch in six days and the adult stage is reached in about 3 weeks.

Often lice are taken up accidentally while one is travelling and in a few days may spread to all of the members of the household.

Control.—Prevention is the wisest course. Meticulous care of clothing and body, care and watchfulness during journeys, careful attention to children, especaillay after contact with other children will prevent these pests from becoming established.

Control of head louse.—Bathe and comb the hair and rub in well a vaseline ointment, which will suffocate the insects. Renew application until cure is complete.

Control of body louse.—This is the form most commonly found in military camps and similar places. It transmits typhus fever. It hides in the seams of clothing where also it lays its eggs. Apply mercurial ointment, camphorated oil, or eau de Cologne. Boil the garments, change clothing often.

Control of the pubic or "crab" louse.—Mercurial or sulphur ointment followed by a warm bath 24 hours later.

Mosquitoes. (*Culex pipiens* L. et al).

These insects occuring in hugs swarms over considerable areas render many beautiful spots uninhabitable. They are particularly abundant in marshy places.

Description and Habits.—Frail, two winged insects with long slender legs, emitting a shrill note by the vibration of their wings.

The eggs are laid in water or in moist places. The larvae live in stagnant water such as is found in swamps, ditches, rain water reservoirs and places where small amounts of water might collect. They come to the surface to breathe, and feed on various forms of organic matter. The larvae become full-grown in a week. The females feed on human blood. *C. pipiens* hibernates in the adult stage.

Control.

(1) Prevent breeding by filling in, levelling or draining their breeding places.

(2) Where it is impossible to drain or where immediate treatment is necessary, cover the surface of the water with a film of kersosene. Crude petroleum is generally used.

(3) For personal protection in the woods a veil of mosquito netting or brussels netting may be used or one of the following preparations may be rubbed on face, hands and neck.

(a)
Tar 3 oz.
Castor Oil. 2 oz.
Oil of Penny Royal. 1 oz.
Mix with aid of heat.

(b)
Oil of citronella 1 oz.
Camphorated alcohol. 1 oz.
Oil of cedar ½ oz.
Easily made, effective.

(c)
Castor Oil.
Alcohol.
Oil of Lavendar } in equal parts.

(d)
Oil of eucalyptus 2 oz.
Carbolic acid (liquid) 4 drops.
Oil of citronella 2 oz.
Castor oil 3 oz.

(e)
Olive oil 3 oz.
Oil of citronella 3 oz.
Oil of penny royal ½ oz.
Oil of cedar. ½ oz.
Camphorated alcohol. ½ oz.

(f)
Oil of mint 1 oz.
Oil of cassia 2 oz.
Vaseline 2 oz.

Some persons may be sensitive to certain of the above preparations and should be careful to choose that which has the greatest efficiency combined with the minimum of irritation.

To drive mosquitoes from a tent or house, burn pyrethrum powder on an iron plate.

III.—INSECTS AFFECTING FOODS,

The insects attacking foods which are most commonly found in houses are: cockroaches, meal worms, meal moths, larder beetles, blowflies and ants.

Cockroaches (Ectobia germanica L.)

In tropical countries cockroaches are pests of the first importance. In our climate the damage is not so great, often negligible, but their habit of frequenting places where food is kept and the characteristic odour which they leave in their trail render them undesirable and repugnant.

Cockroaches may be found in the cleanest dwellings, but they normally frequent dirty places where they are not ordinarily disturbed. The German cockroach (*E. germanica*) is the one most frequently found in Quebec. It is not as offensive in its odour as the larger American cockroach (*P. americana*) which, however, is seldom found here.

Description and Habits.

E. germanica measures ½ to ¾ inch in length. The body is flattened and yellowish-brown in colour. The oriental cockroach (*Blatta orientalis*) is very rare. It is ¾ to 1 inch long and is blackish in colour. The American cockroach (*P. americana*) is occasionally found in the southern part of the province. It is larger than the two other species (1¼ to 1¾) and of a deep brown colour.

All three species frequent dark, warm places. The neighbourhood of chimneys and stoves, crevices in floors and walls, the shelter of carpets and hangings, and the obscurity back of posts and pillars between these and the walls, all serve as hiding places. Of nocturnal habits, they issue forth at night and invade cupboards, sinks, and pantries. They run rapidly but never fly in spite of their well developed wings. The eggs numbering about thirty are contained in a cylindrical brown sac which the female carries around with her until near the time of hatching. The young nymphs are very active. They moult several times, attain their wings and become adult in about three months.

Control.—It is necessary to emphasize here the need for perseverance in the eradication of cockroaches, since repeated applications of insecticides must be made before complete control is obtained. We are able to say from experience, however, that if the insecticide be applied twice a week for one month the pests will disappear.

We recommend the following:

(1) *Pyrethrum.*—Apply with a bellows to crevices, cracks and other places of refuge. The insects become stupefied and helpless, leave their retreats, and large numbers may be killed after each application. Repeat the dose two or three times a week since the powder loses its strength after 24 hours exposure to the air.

(2) *Borax.*—Applied in same way, pure or mixed with chocolate. Costs little and gives good results.

(3) *Sodium fluoride.*—A very excellent remedy. May be applied pure or mixed with flour. Somewhat poisonous to man, so should not be allowed to get on foods. Spread around sinks, stoves, in cracks and crevices of floor and walls, it will destroy quickly all cockroaches which feed on it.

(4) *Fumigation.*—As a last resort we may fumigate with hydrocyanic acid gas as described at the end of this paper. A single room or the entire house may be fumigated.

The Meal worm. (*Tenebrio melitor L.*)

The meal worm adult is a dark brown beetle, ¾ inch long, and slightly flattened. It attacks all kinds of meals and other cereal products.

Description and Habits.—The eggs are laid in flour or meal. The larva is cylindrical, long and narrow, shiny yellow in colour and about 1 inch long. It completes its development in about three months. The adults fly about in the spring, enter houses and start new infestations.

Control.

1. Purchase only non-infested cereals.
2. Store cereals only in receptacles that can be hermetically closed. Clean receptacles thoroughly before putting in new supply.
3. Heat infested bins for 6 hours at a temperature of 120°-125°F.
4. Before using infested meal, sift and burn the siftings which will contain the larvæ and eggs.
5. In case of an epidemic fumigate. This is the method in general use in mills.

Meal Moths. (*Pyralis farinalis L.* et al.)

The term "meal-moth" or "flour-moth" is used for several species of insects, the larvæ of which are very destructive pests of cereals. Meal and cereals even in sealed packets are often infested. The larvæ spin nets or tubes of silk within which they feed. Sometimes the whole mass of meal is bound together by these silken threads and rendered absolutely useless.

Description and Habits.—The eggs are laid in the flour or on the sides of the containing sack. The larvæ are whitish with black spots along the back. They measure about ½ inch when full grown. They reach maturity in about 40 days and it is during this time that the damage is done to the meal on which they are feeding. The adult is a small greyish moth with a wing expanse of ⅞ inch.

Control.—Cleanliness, care of cereals, closed bins, heat and fumigation as in the case of the meal worm.

The Larder Beetle (*Dermestes lardarius L.*)

This insect feeds on hams, fats, bacon and other kinds of meat. Badly constructed cupboards, warm and without aeration are the places where they occur abundantly.

Description and Habits.—The adult is a small greyish beetle, ½ inch long. It migrates at the beginning of the summer, at which time it may be seen in houses, running around or resting on curtains, window-ledges etc. The eggs are laid on fatty matter. The brown, hairy, active larvæ feed on meats, hams, cheeses, fats, hides etc. boring galleries through the material on which it is feeding. There is one generation a year.

Control.

1. Keep the larder in a clean condition and well ventilated. Openings for ventilation should be covered with mosquito netting.

2. Ham, bacon, fatty material etc. should be kept in a closed receptacle or wrapped carefully in wax paper.

3. Make a trap for the adults by placing a piece of ham beneath a plate. The insects are attracted to the ham and may be killed every two or three days.

The Blow Fly. (*Calliphora vomitoria L.*)

Like many other species of flies the blow flies are attracted to decaying meats in which they lay their eggs.

Description and Habits.—A large black fly with metallic blue abdomen. The female lays her eggs on meat and the bodies of dead animals. Each female lays from 400 to 600 eggs which hatch in a very short time. The insect passes through all stages of its development in less than a month. The larvæ or maggots feeding on meat render it unfit for food. The blow fly prefers decaying flesh and in nature hastens the destruction of organic matter.

Control.—See that all provision cupboards are fly proof. Do not allow meat to become tainted.

Ants.—(*Monomorium spp.* et al).

These insects sometimes invade houses and frequent kitchens, pantries, cupboards etc. They are very annoying and difficult to eradicate.

Description and Habits.—The species usually found in houses (*Monomorium minutum* Bokley) is a small black insect, which normally lives outdoors.

In the more temperate southern region the small red ant, *M. pharaonis* which nests in the walls and beneath the floors is a veritable plague. All colonies of ants contain neuter workers, winged mates and females and one queen. The queen lays an enormous number of whitish eggs which the workers care for. The workers also feed and care for the larvæ. The pupæ are white and cylindrical. If the nest is disturbed the workers seize the pupae and carry them to safety. The pupæ are often thought to be eggs by the uninitiated.

Control.

1. Pour large quantities of boiling water or kerosene into the nests.

2. *Poisons* (a) Sodium fluoride either alone or mixed with sugar, distributed in places frequented by the ants.

(b)	Sugar	1 lb.
	Sodium Arsenite	125 grains.
	Water	1 pint.
	Boil and stir well.	
(c)	Granulated sugar	4 lbs.
	Water.	1
	Tartaric acid	3 gms.
	Benzoate of soda	3 gms.

Boil the ingredients together for half an hour. Prepare a second solution by dissolving in a separate receptacle ½ oz. sodium arsenite in 3 fluid oz. of warm water. When the two solutions are cool pour the first into the second stirring vigorously. Then add $^2/_3$ lbs of honey and mix well. Impregnate bits of bread with the mixture and put them in places frequented by the ants. The poison works slowly, but within three weeks the colony should be exterminated.

This poison may also be used against ants in lawns and gardens.

3. *Repellants.*—A cayenne pepper stuffed with a wad of cotton impregnated with benzene. Sugar on which has been poured a few drops of turpentine.

IV.—INSECTS INJURIOUS TO CLOTHING' RUGS FURS, ETC.

Insects destructive to woolens, furs, museum specimen, books, etc., are clothes moths, of which there are three distinct species, carpet beetles, museum beetles and the silver fish.

Clothes Moths (Tinea spp.)

Each year about the month of June, small silver grey moths may be seen in the evenings flying about indoors. These are adult clothes moths, the larvæ of which cause so much damage to furs, woolens, etc.

Description and Habits.

The eggs are laid on woolen fabrics, skins etc. and hatch in 7 to 10 days. The habits of the larva varies according to the species to which it belongs.

The Case-Making Clothes Moth. (*T. pellionella L.*) constructs a case of wool, hair or feathers within which it lives and which it carries about from place to place.

The Webbing Clothes Moth. (*T. biselliella* Hum) is commoner than the case-making clothes moth and multiplies more rapidly. There are at least two generations a year. The adult is pale yellow. The eggs hatch in about seven days. The caterpillars do not make a case but secrete a silken thread with which their spin a silken pathway as they advance. They feed on furs and woolens throughout the year.

The tapestry moth (*Trichophaga tapetzella*) is rarer than the two others. The adult is gray and black. The larva burrows tunnels in the substances on which it feeds.

Control.

There are several preventive measures which may be employed satisfactorily against the clothes moth. Indeed the only satisfactory method lies in preventing injury, since it is usually impossible to repair the injury caused by these insects.

1. Expose all woolen clothing etc. to sunlight and air. Beat and brush thoroughly all furs and woolens which are used only in winter and keep in sealed bags or at low temperatures during the summer. Paper sacks specially made for this purpose may be purchased. Their value depends on the thickness of the paper and their ability to be hermetically sealed.

2. *Red cedar chests* are useful for storing clothing etc. The odorous emanations from the wood kill the larvæ of the moth. Before storing, the clothing should be placed in the sun and brushed thoroughly. The chest should be kept tightly closed.

Clothing may be stored similarly in other kinds of chests or trunks provided naphthalene (1 or 2 lbs) be placed between the clothing.

3. *Naphthalene* placed in cupboards acts as a repellant.

4. Washable woolens should be washed and wrapped in a stout sheet of paper with naphthalene. The odour of naphthalene disappears when the clothing is aired.

5. *Fumigation.*—If, in spite of these precautions, the moths are still troublesome, we should resort to fumigation using sulphur in the rooms and carbon bisulphide in the trunks. (See beyond for methods).

Carpet and Museum Beetles. (*Anthrenus spp.*)

These are small beetles of the same family as the larder beetle previously discussed.

The larvæ feed on woolen material, carpets and rugs and on collections of insects and other animals in museums.

Description and Habits.—There are two well defineds pecies. The buffalo carpet beetle (*Anthrenus scrophulaniæ* L.) is oval, robust with red, black and white marking on the elytra. It usually attacks woolens although in Europe, its native home, it is chiefly a pest of museums. The adult lays its eggs on the wool of carpets and clothing. These eggs hatch in a few days. The larvæ are a quarter of an inch long and bear tufts of brown hairs on the sides and tip of the abdomen. It is very active and develops rapidly. There are two generations a year. The adults are rarely seen in houses but may be found in early summer feeding on the pollen of flowering plants.

The museum beetle (*A. piceus* Oliv.) is entirely black. The larva is primarily a pest of museums but injure also woolens, carpets and feathers. Unless one guards against it, this pest will often destroy insect collections completely.

Control.

Lift carpets, beat them and spray with gasoline or benzine.

Wash floors with soap and water; spray with gasoline or benzine; fill up cracks, which serve as hiding places for the larvæ, with mastic.

Place naphthaline flakes beneath rugs and in museum cases.

The methods advised against clothes moths will also serve to control these pests.

Where there is a serious epidemic, recourse should be had to fumigation.

The Silver Fish (*Lepisma saccharina* L.)

Description and Habits.

A small apterous, primitive insect having three long thread like appendages at the hinder end. The body measures about 1-3 inch in length and is covered with shiny silver gray scales. The insect moves rapidly on its long active legs.

The silver fish feeds chiefly on starch and glue and will injure book bindings, wall paper, gummed labels, food stuffs and clothing containing these substances. They are particularly injurious in libraries.

Control.

Poison with fresh pyrethrum powder or with sodim fluoride sprinkled in their haunts.

A very good method is to distribute in the places which they frequent, bits of paper or cardboard smeared with a paste made as follows:

Sweetened glue	½ pint.
Arsenate of lead or Paris green	1 teaspoonful.

V.—FUMIGATION METHODS

The three fumigants in common use are sulphur dioxide, carbon bisulphide and hydrocyanic acid gas. These substances differ in their toxicity and in their effectiveness.

1. *Sulphur.*

Many persons, thinking sulphur a stomach poison scatter it about in dwellings to control household pests. This is quite useless. It will be remembered, however, that like other animals, insects respire air and deleterious substances can be taken into their breathing pores with the air. The fumes of sulphur is such a substance and the burning of sulphur is one of the principal methods used in the control of household insects. If in any closed space one burns a sufficient quantity of sulphur, most of the insects in the space will be killed. Commonly, however, the householder uses an insufficient amount and the process must be repeated. If the space is air tight, one lb. of sulphur per hundred cubic feet should be sufficient, but as most rooms have cracks in

doors, windows or walls through which the fumes may escape a larger dosage is often necessary.

There are certain disadvantages in the use of sulphur. The sulphur dioxide fumes will bleach the colours of wall paper, curtains, cloths etc., They will also tarnish metals. It is advisable therefore before fumigating to remove as far as is possible all metals and colored fabrics from the room.

Method of Procedure.

There are four essential points to be remembered.

(a) *The room must be air tight.*—Examine carefully the doors, windows, floors and walls; stop all chinks by plugging or by pasting strips of paper over them. The fumes should circulate freely through all parts of the room, to this end all cupboards and drawers should be opened and furniture which may serve as an obstacle to free circulation should be shifted.

(b) *Use a sufficient quantity of sulphur.*—This is absolutely necessary to success. Even for a small room one pound of sulphur is seldom enough. Depending on the degree of tightness in the room, two to five pounds of sulphur per 500 cu. ft. should be used.

Sulphur candles of various sizes may be purchased at the drug stores. Do not follow too closely the directions as to quantity given with the candles but estimate the amount to be used in accordance with the condition of the room.

(c) Place the sulphur candle on a brick which rests in a *basin of water* so as to remove all danger of fire through the falling of the candle. Light the candle and leave the room, sealing the door as tighly as possible.

(d) *Duration of fumigation.*—Fumigation should continue for at least three hours or preferably overnight if this is possible.

Before using the room aerate it thoroughly to remove the characteristic sulphur odour.

Note.—Since sulphur does not kill the eggs, a second fumigation a fortnight later is advisable. This will kill the insects hatched during this time.

2. *Hydrocyanic Acid.*

Hydrocyanic acid gas is one of the most deadly poisonous substances known. It is obtained by the action of dilute sulphuric acid on potassium cyanide. Owing to its high toxicity this gas should be handled only by experts. In cities and towns the board of health inspectors, and in the country the local physicians are qualified to use the gas without undue danger. Most gardeners and florists also use it in fumigating their greenhouses and nursery stock.

Method of Procedure.

(a) The operation must be in charge of a *competent person*.

(b) *Make the room as air tight as possible.* Loss of gas reduces the efficiency without counting the grave danger to the operator and to other persons in the vicinity.

(c) *Calculate the quantities of the ingredients needed.*—This is very important The ingredients for fumigating 100 cubic ft. are:

Potassium cyanide	1 oz.
Commercial sulphuric acid	1 fluid oz.
Water.	3 " "

Eg. A room 20 ft. long, 15 ft. broad and 10 ft. high, i. e. 20x 15 x 10 — 3000 cu. ft. would require.

Potassium cyanide	30 oz.
Sulphuric Acid.	30 oz.
Water.	90 oz.

(d) *The three constituents must be mixed carefully* in the following manner: Spread several large sheets of paper on the floor.

Place on the papers and earthen waste pot or basin. Do not use wooden or metal receptacles as these are injured by the acid.

Pour the necessary quantity of water into the receptacle.

Pour in the sulphuric acid slowly.

On adding the cyanide the poisonous gas is evolved rapidly, so this must be done with great care. Place the exact quantity of cyanide in a paper sac and suspend the sac above the receptacle by a string, the other end of which passes to the outside of the room through a small opening.

Having made these preparations, leave the room, close the door and plug any openings in it, then detach the string so that the paper sac containing the cyanide falls into the receptacle of water and sulphuric acid.

By following this method the poisonous gas is not evolved until the operator is outside of the room and free from danger.

The room should be left closed for at least one hour, preferably two or three.

At the end of this time open a window or door, taking care not to breathe until a safe distance away. The gas dissipates rapidly but half an hour should be allowed before the room is entered. The outer windows should then be opened to complete the aeration of the room, which should be ready for use in another couple of hours.

Remarks.—Always add the acid to the water. If water is added to the acid, the two will mix so violently that the mixture may be spilled. If the quantity of cyanide required exceeds one pound, it is better to use two receptacles.

If all of the rooms in a house are to be treated, each one should be measured separately and fumigated separately. As the gas is lighter than air and moves upwards, the operation should commence on the top floor.

The gas does not affect colours, tissues or metals, so it is unnecessary to remove furniture and linen before fumigating.

As far as foods are concerned it is necessary to distinguish between those that contain water, such as milk, butter, fresh meats, etc. and those which

are dry, such as meals, bread and spices. The former should be removed during fumigation as the moisture absorbs a little of the gas.

One such fumigation should kill all insects in the room with the possible exception of the eggs of some forms. Rats and mice also succumb to the fumes.

3. *Carbon Bisulphide.*

Carbon bisulphide is a heavy liquid with a very disagreeable odour. It changes readily into a highly inflammable gas which is toxic to insects. It is used chiefly for fumigating substances which can be placed in a box, chest or other close receptacle.

When inhaled by man the gas produces nausea. Because of its inflammable nature fire of any sort, pipes, cigars lighted matches, lamps, etc. should be kept away from it.

Method of Procedure.

Choose a box, chest or other receptacle which can be made airtight. Place in it the objects to be fumigated—meal, peas, beans, clothing etc.

Place a plate on the top of the articles, and pour the bisulphide in it at the rate of two ounces per 100 cu. ft, then cover the receptacle making it air tight if possible.

The treatment should last for 48 hours or longer.

Carbon bisulphide does not injure fabrics or metals but its inflammable nature demands great care in the handling of it.

THE SHADE TREE INSECTS OF EASTERN CANADA FOR THE YEAR 1925, WITH REMARKS ON THEIR ACTIVITIES AND PREVALENCE

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Insects affecting shade trees throughout Eastern Canada were, in general not so severe in their attacks during the past season of 1925. There were, however, certain infestations which were spread over wide areas and severe enough to be considered as epidemic; as, for example, the maple leaf cutter, *Paraclemensia acerifoliella* Fitch, which infested sugar maples throughout Southern Quebec and Eastern Ontario; the birch leaf skeletonizer, *Buccalatrix canadensisella* Chamb., abundant on birches everywhere; the larch sawfly, *Lygaenematus erichsonii* Hart., affecting the larches in New Brunswick and Prince Edward Island; the felted beech coccus, *Cryptococcus fagi* Barnsps., in Nova Scotia; and others.

Possibly the irregular unseasonable weather conditions had something to do with the lessening of insect activities. The spring was cold and deferred, in fact it was June before the temperature showed much indication of rising, when it suddenly jumped to the other extreme, and in some places the mercury was over 90°F. The latter part of June and most of July was raw and wet, whereas August was quite the reverse, very hot and very dry, followed by an abnormally cold, wet September. It is likely, therefore, that these sudden changes and low temperatures had a marked controlling influence on insect development and activities.

There was an abundance of vegetation everywhere, the foliage of the maples and elms being particularly thick.

In the following, the more important insects of the year are enumerated and a short discussion bearing on some point regarding their prevalence or extent of injury, life-history and control follows each.

The Maple Leaf Cutter, *Paraclemensia acerifoliella* Fitch.

For the past two years this insect has been particularly numerous on sugar maples and a number of inquiries respecting injury done by it have been received at Ottawa. Every sugar bush, possibly, in the Eastern Townships and many others in Eastern Ontario were heavily infested. At Frelighsburg, Que., an entire hillside covered with fine maples appeared as if badly scorched. We have been making some studies on its life-history and find that it attacks beech severely and will also feed on elm sparingly; but strange to say does not care for red maple. Some marked instances of this preference were observed near Ormstown, Que. We have recommended burning the fallen leaves late in autumn since the larvæ pupate in the litter. This can be safely carried out if the rubbish is drawn well away from the tree trunks, raked into small piles and the burning carefully watched.

The Maple Borer, *Glycobius speciosus* Say. This injury was noticed in many groves. The beetle is a formidable enemy of sugar maples and while its average numbers may be small in the ordinary grove and injuries appear of little consequence, it does do a great deal of serious damage each year. During the past season it was reported throughout Huntington County, Quebec, as being particularly severe. In one grove of 2000 trees at Franklin Centre, Quebec, at least 75% infestation was noted.

One of the widest epidemics of leaf feeders recorded in 1925, was that of the birch leaf skeletonizer, *Buccalatrix canadensisella* Chamb. Everywhere the white and yellow birch were growing, this small caterpillar was to be found. The majority of trees appeared as if fire had passed over them, and their blighted condition attracted the attention of even a casual observer. Records from the United States show that this pest was epidemic throughout the New England States and the State of New York. Fortunately, the damage that the birch leaf skeletonizer inflicts comes toward the end of the summer season and is, therefore, not so serious as it might otherwise be.

The Brown-tail Moth, *Euproctis chrysorrhoea* L. This destructive European species was first discovered in Nova Scotia in 1907 and a few years later it had spread to the province of New Brunswick. A maximum infestation was reached in 1913-1914 when one-third of Nova Scotia and three-fourths of New Brunswick were overrun with this plague. During that year over fifty thousand nests were collected by scouts. Other control measures consisted in banding trees, spraying, and the breeding and liberating of countless thousands of parasites, with the result that in 1916 the infestation had become greatly reduced, and by 1917 not a nest was found in New Brunswick. Scouting was kept up, however, until 1922 and then discontinued. In Nova Scotia there was a gradual falling off in the number of nests collected so that by 1924-1925 only one hundred and fifty-four nests were taken, and in 1925-1926 this number was further reduced to seventy-seven.

The Gypsy Moth, *Porthetria dispar* Linn. In 1923 a local outbreak of this moth was discovered about half a mile from the Quebec border. The following year intensive scouting plans were put into effect by the Entomological Branch in co-operation with the Quebec Provincial Department of Lands and Forests, and in July 1924 the first egg-mass was discovered in Canada near Beebe, Stanstead County, Que. Further careful inspection work revealed a local outbreak near Henrysburg, St. Johns County, covering about one-third of a mile. As soon as this was known, intensive clean-up operations were begun in the spring of 1925, and a most careful inspection of all trees, buildings, stone walls, etc., was carried out which resulted in locating about three thousand egg clusters. Trees were banded and sprayed with two lead arsenate sprays of 16,000 gallons each and applied in June by a high power outfit supplied by the Federal Government of the United States. In the fall the entire ground was again gone over and only four egg masses were found.

The Spring Cankerworm, *Paleacreta vernata* Peck. Cankerworms were present in a number of localities. An outbreak occurred in June at Gatineau Point, Quebec, extending about a mile along the bank of the Ottawa river and for half a mile inland. All maple, ash and elm in that locality were severely attacked and some trees completely defoliated. Another centre of infestation was along the Rideau river banks and the district surrounding the southern boundary of Ottawa city where elm, maple, apple, pin cherry and other trees were stripped.

The Green Maple Caterpillar, *Xylina antennata* Walk. Closely following the spring cankerworm outbreak at Gatineau Point district was one of the green maple caterpillar. These light green larvæ with their characteristic white lateral bands have a special liking for spot maples. What the cankerworms left the green caterpillars destroyed, as well as feeding freely on the lower shrubbery, wayside plants and vegetation along the waterfront.

Elm Leaf-Miner, *Kaliofenusa ulmi* Sund. Elms in Huntingdon County were again badly defoliated by the leaf miners. Some of the trees suffered particularly and the foliage of young trees on the high ways were brown and badly blistered.

The White-Marked Tussock Moth, *Hemerocampa leucostigma* S. & A. Reports received from Toronto city show that the white-marked tussock moth injury was particularly severe in that city and suburbs. The egg clusters were so numerous on the trunks of many of the large trees on Jarvis Street and the central parts of the city that they attracted considerable attention. In Montreal city where the tussock moth has been established for many years the infestation was not so severe. In the fall, a careful examination revealed only two clusters in Lafontaine Park and correspondingly few in the central and western sections of the city. This improvement is likely due to the organized control methods carried out by the city authorities.

Tent Caterpillars, *Malacosoma disstria* Hubn., and *M. americana* Fab. were reported this year as not being so abundant in New Brunswick. At Fredericton and Woodstock, N. B., a marked decline in infestation was noticed, and at Douglas, N. B., which is a well-known centre for these pests, only two webs were located. In Quebec province, Roxham and Henrysburg reported increased activities and at Pelee Island, Ont., elm, butternut, walnut, apple, and cherry were attacked.

The Larch Case-Bearer, *Coleophora laricella* Hubn., was abundant throughout the whole of New Brunswick. Severe defoliation also took place in the Annapolis Valley, specially at Annapolis Royal, and in parts of southern Quebec.

LeConte's Sawfly, *Neodriprion lecontei* Fitch, which was so destructive in 1923-1924, gave little or no trouble this year. It is thought that the parasite *Exenterus diprioni* Rohwer, which was abundant, was likely an important controlling agent.

The European Pine Shoot Moth, *Rhyacionia buoliana* Schif. The first record of this larva in Canada was from a Toronto district in the early summer of

1925, and was taken on imported nursery stock. On account of the pest being considered very serious it was thought advisable to have all shipments of pines imported since 1923 inspected. This revealed a Dominion-wide distribution from Halifax to Vancouver, and when a more detailed inquiry was made, it lead to the belief that the pine shoot moth had been established in Canada for, possibly, twelve or thirteen years.

The Felted Beech Coccus, *Cryptococcus fagi* Bärensp. is a destructive scale which has been introduced from Europe and become established on the beeches in Nova Scotia and Prince Edward Island. Throughout the central and southern parts of Nova Scotia the trees are reported to be in a very serious condition, and there is considerable apprehension as to the losses it has already brought about, the gradual spreading of the trouble to fresh areas being a source for further anxiety. These minute scales secrete large quantities of wool-like wax which spread over the bark surface coating it with a thick, white, felt-like material. The trees eventually succumb to the attack.

June Beetles, *Phyllophaga* sp., were remarkably abundant during the early summer. From various parts of Ontario and Quebec came reports of heavy flights. No less than thirty-five thousand were collected from five light-traps set out in the neighbourhood of Hemmingford, Quebec, and records there show that elm and silver-leaf poplar, maple, willow and other shade trees were completely stripped of their foliage. In the district of Annapolis, N. S., June beetle flights for 1925 were in excess of those of the previous year. Heavy flights occurred in western Ontario, specimens collected at Strathroy proved to be the species *Phyllophaga rugosa* Welsh.

Western Ontario suffered from the yellow-striped oak caterpillar, *Anisota senatoria* S. & A. In Kent county the white oaks were stripped severely and at Windsor, Ont., the oaks in the municipal park and surrounding district were so badly attacked that the leaves were completely skeletonized. The young larvæ of this species are gregarious and have the habit when feeding of ranging themselves systematically along the edge of a leaf, or in apparently organized groups, and in this way they not only quickly but completely remove the upper and lower green leaf surfaces. As they grow bigger they eat the smaller veins, and later on the larger leaf structures, so that eventually only the mid-ribs are left.

Complaints came from Nova Scotia in July that the Spiney Elm Caterpillar, *Aglais antiopa* Linn. was causing damage in the Annapolis Valley district. Elm and poplar suffered chiefly from their attacks. This species, the mourning cloak butterfly, has two broods, the second of which winters in the adult form and is one of our first butterflies to be seen in the springtime.

Larches in New Brunswick and Prince Edward Island appeared affected with the Larch Sawfly, *Lygaeonematus erichsonii* Hrt., and severe defoliation occurred in many localities.

The ugly nests of the Fall Webworm, *Hyphantria cunea. Cunea Drury.* Drury, were again present in many parts on a variety of hosts, chiefly elm, ash

and willow. These infestations, however, did not appear so numerous as in 1924.

Among other shade tree pests recorded were:

Elm Bark Louse, *Gossyparia spuria* Modeer, in Hull, Que., Windsor, Ont., and Ottawa.

White Pine Bark Aphis, *Chermes pinicorticis* Fitch, in New Brunswick.

Bronze Birch Borer, *Agrilus anxius* Gory, general.

Butternut Woolly Aphis, *Monophadmus caryæ* Norton, reported at Lennoxville and Franklin Centre. This is rare and is our first record.

Cotton Maple Scale, *Pulvinaria vitis* Linn., reported from Montreal, Ottawa, and other centres.

Lilac Leaf Miner, *Gracelaria syringella* Fab., severe in Ottawa and Toronto.

INSECTS OF THE SEASON IN SOUTHERN QUEBEC FOR THE YEAR 1925

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Maple Leaf-cutter (*Paraclemensia acerifoliella Fitch*).
The destructive work of this insect assumed tremendous proportions this year in the maple woods of Southern Quebec. It was very common over the entire district and the foliage presented a very dilapitaded appearance. The brownish color the leaves took on early in July was plainly visible for a long distance. The present outbreak easily surpasses any other since the establishment of this laboratory.

Leaf-miner in Carolina poplar.
Reports of injury were received from Knowlton and Hemmingford, Que. Attemps to raise the adults have so far failed.

Larch Case-bearer (*Coleophora laricella* Hubn.)
It was very common around Hemmingford and the affected trees were much defioliated. A few large larch trees near a house at Compton were seriously injured.

Cedar or Arbor Vitae Leaf-miners (*Argyresthia thuiella Pack.& A. freyella* Wals.)
They were very common over a large area around Hemmingford. The foliage of the trees was blotched due to the light brown areas caused by insects being mixed with the natural green color.

Woolly Gall (*Andricus lana* Fitch).
This insect was very common on Russian oak at Knowlton.

Spring Cankerworm (*Paleacrita Vernata* Pack.)
The caterpillars were very common on apple around Abbotsford and Hemmingford and defoliated a large block of American elm at Chateauguay Basin.

Tent Caterpillar (*Malacosoma americana* Fabr.)
This captepillar has not been very common for the past twelve years in southern Quebec but this year there was a considerable increase along the roadsides and in some orchards at Henrysburg.

Spotted Willow Leaf-beetle (*Lina lapponica* L.)
Very destructive to foliage of Virginia creeper at Chateauguay Basin and Covey Hill.

June Beetle (*Phyllophaga anxia* Lec.)
A very heavy beetle flight this year. Elms, oaks, butternuts and several other kinds of trees defoliated. Cultivated raspberries were also seriously defoliated at Hemmingford.

Cutworms.
Cauliflower, cabbage and gladiolus were often cut-off at Hemmingford and a half-acre of potatoes was destroyed at Havelock.

Cabbage-Maggot (*Phorbia brassicae* Bouche).
Found severely injuring cabbages in Montreal West.

Onion Maggot (*Phorbia ceparum* Meig.)
Found severely injuring onions on the Island of Montreal.

Carrot Rust fly (*Psila rosae* Fab.)
Caused 25% damage to carrots in gardens at Hemmingford.

Wireworms (Elateridae).
The corn test plots at the Dominion Experimental Farm, Lennoxville, Que. were ruined by wireworms, and potatoes in some instances near Hemmingford were riddled with their borings.

Clover-head Weevil (*Tychius picrirostris*).
Found very commonly on clover heads at Covey Hill, Que.

Green Cabbage Worm (*Pontia rapae* L.)
It was very common at Hemmingford. The pupae were 35% parasitized by *Pteromalus puparum* and a braconid, which has not yet been determined, parasitized some.

Plum Curculio (*Conotrachelus nenuphar* Hbst).
This oft troublesome beetle to apples especially, in this province, was mush less injurious than usual. Only a few orchards were seen in which it was serious this year.

Apple Curculio (*Tachypterellus quadrigibbus* Say).
This beetle was the second most serious fruit pest this year. In all the fruit districts it was troublesome but it was most serious in Abbotsford. This may have been due to a large extent to the use of a low grade calcium arsenate.

Apple-Case-bearers (*Coleophera pruniella, C. fletcherella and C. maliorella*).
The first mentioned is supposed to be a new economic case-bearer for

apples and it was almost the only species doing damage at Lachine. At Chateauguay, *pruniella* and *fletcherella* were about even in numbers with probably 5% *malivorella*. The case-bearers are annually destructive to apple foliage along the Lake St'. Louis water-belt.

Round-headed Borer (*Saperda candida* Say).

This has been and continues to be a very destructive pest to young apple trees. It is responsible for large numbers of trees dying annually and weakens equally large numbers. Unless one is observant it causes considerable injury before it is detected. It is present in all our fruit growing areas south of the St. Lawrence river and due to the peculiar type of orchard site predominating it will continue to be one of our most injurious insects.

Apple Maggot (*Rhagoletis pomonella* Walsh).

This insect was this year, as very often in the past, the most destructive fruit pest in the province. It was very prevalent in some district and caused very heavy losses. The flies did not appear in any numbers until much later than is usual.

Cranberry Rootworm Beetle (*Rhabdopterus picipes* Oliv.)

It was found last year in one orchard at Rougemont where it did extremely serious injury to apples. This year it had spread in that district and was taken from apples in several orchards but it was not present in numbers sufficient to cause much loss. It has also been taken at Hemmingford from a considerable number of plants but was not found on apple.

Aphids.

For the first time since the establishment of this laboratory these insects caused considerable injury to large apple trees here. They have often been quite injurious to young trees and were extremely so this year. The attacks this year will certainly result in stunted nursery stock for 1926.

Codling Moth (*Carpocapsa pomonella* L.)

Ten years ago this insect was very uncommon, especially in sprayed orchards, and hardly an injured apple could be found. During the past few years it has increased enormously and the "side-worm" type of injury has caused considerable losses in many orchards, especially in Rougemont and St. Hilaire; the latter has probably suffered most.

Budmoth (*Tmetocera ocellana* Schiff.)

This year the loss due to this annual pest was much less than normal in sprayed orchards. Extremely few buds were injured and scarcely an apple was noticed with the fall-feeding injury.

Blister Mite (*Eriophyes pyri* Pag.)

It was very common on wild trees and in unsprayed orchards but was not of much importance in well sprayed orchards. It was, however, fairly common in some orchards at Rougemont.

Poplar Borer ((*Cryptorhynchus lapathi* L.)

Carolina poplars were found infested with these borers at Huntingdon and East Angus. Following a storm several of the trees were broken off a short distance from the ground. Several borers were taken from indidivual trees not more than an inch in diameter.

Slugs.

The home gardens in Montreal West were severely injured again this year. A five-acre field of corn was badly injured at Hemmingford, especially around the edges.

THE HENRYSBURG OUTBREAK OF THE GYPSY MOTH IN QUEBEC.

By S. H. Short, Entomological Branch, Department of Agriculture, Ottawa.

In controlling insect pests, the truth of the adage that "an ounce of prevention is better than a pound of cure" is well illustrated, and in no case more clearly, than in the history of the gypsy moth in North America. In 1869, a scientist at Medford, Mass., imported from Europe a few specimens, thinking they might be used in the silk industry. Some individuals escaped from his laboratory but despite his warning to the authorities, the danger was disregarded until, a few years later, a serious infestation occurred. The subsequent struggle to eradicate this pest in large areas of the New England States is still going on.

It was inevitable that sooner or later the gypsy moth would reach Canada; fortunately, due to unceasing vigilance its presence was discovered early and hence the area of outbreak was small.

The "Henrysburg infestation", as this outbreak is called, is located in Lacolle township, St. John's county, about three miles north of the international boundary. It extends over seven farms and is approximately one third of a square mile in area.

Here the forces of the Entomological Branch, Department of Agriculture, Ottawa, in co-operation with the Department of Lands and Forests of the Province of Quebec, have been concentrated for definite periods, in an effort to eradicate this outbreak. A few notes on the difficulties met with and the methods followed may be interesting.

The first steps towards prevention of spread and eradication were taken in the autumn of 1924, after the egg laying season. All egg masses which could be located were destroyed with creosote. In all 2885 egg masses were discovered previous to the spraying carried on in 1925, whereas after the completion of the season's clean-up work, a reinspection of the area resulted in the discovery of only four additional egg masses.

To find these egg masses necessitates the turning over of stones in stone fences and stone walls, as well as the examination of buildings, debris, boards and other

objects, under which egg masses may have been laid. It is interesting here to note that the female gypsy moth does not fly owing to the comparatively heavy weight of the abdomen. The eggs may be laid a few inches from her place of emergence, but they are generally deposited immediately adjoining the pupal case; and as the caterpillars pupate on any object, even in holes in the ground or on the leaves of the tree, the result is that eggs may be located anywhere. The favorite locations for pupating and subsequent egg laying include the underside of branches of trees, in stone walls adjoining trees, in the crevises of rough-barked trees such as the willow and on the underside of boards, stones, etc., at the base of the infested tree. To eliminate food material and to facilitate the examination of loosely piled stones, all brush along fence rows and around stone piles was cut and burned. Some 600 yards of stone walls and fences were treated in this manner.

To illustrate the diversified places in which egg masses may be found, it may be stated that 40 were located inside a carriage shed, 54 on one stone near a tree, 8 on a milk stand, 1219 on a willow tree, a total of 1258 on stone walls, 153 on buildings and several on miscellaneous objects.

The following spring, further scouting, including more stone turning and brush cutting, was done to still further reduce the possibilities of the existence of the pest. Just before the egg hatching season, which commences early in June, all trees in the infested area were banded; first, with a special tarry preparation known as raupenleim, which was applied with a special gun. This band is about one inch wide and a quarter of an inch thick and revents caterpillars emerging from undiscovered egg masses on the ground, from climbing the trunk of the tree to the foliage above. Above this band is placed a band of burlap which is about a foot wide, tied in the middle and folded over. Caterpillars crawling down the trunk of the tree in search of a sheltered place to pupate crawl under this band which provides this protection. These traps are examined daily and any caterpillars found are destroyed.

Now for the stone walls; many of these were of so called dry masonry and although they could easily be torn down, it would have been a difficult task to rebuild them. Therefore, to kill the young caterpillars hatching therein from untreated egg masses, a very hot flame was thrown onto the wall. The flame thrower consisted of a forty gallon spray barrel with pressure pump attached. To the outlet of the barrel was attached twenty feet of half inch hose and to the end of the hose was attached an eight foot, half inch iron pipe with a spray nozzle at the end. The barrel was filled with kerosene which was forced through the nozzle under pressure and emerged in a fine mist, which readily ignited and gave a hot penetrating flame.

After the preliminary preventive measures had been taken and the height of the feeding season had come, about the middle of June to the first week in July, the whole infestation was sprayed with arsenate of lead. Two sprays were applied, one between June 24th and 30th and the other July 10-14th. Arse-

nate of lead powder, 25 lbs to 400 gallons (American) of water, was used and in applying the second spray a sticker of fish oil was added. In all 80 tanks or 32,000 gallons of spray were applied using one ton of arsenate of lead, and twenty gallons of fish oil. The spray was applied with a high pressure machine and all foliage was thoroughly covered. The Canadian field force is indebted to the officers of the United States Bureau of Entomology for their co-operation in loaning a high power spraying machine.

In view of the possibility of the further existence of the gypsy moth at Henrysburg and our desire to completely eradicate same from the Province of Quebec, every precaution is being taken to prevent a recurrence of the infestation at Henrysburg. Spraying will be done again in 1926 and after that a thorough reinspection of the infested area will be made.

This briefly is the procedure being followed in the endeavour to control and eradicate the outbreak of the gypsy moth at Henrysburg. In itself it is simple; its efficiency depends upon the careful conscientious work of the field force. A maintaining of the high standard so far attained in this regard will, it is confidently expected, achieve complete success.

THE POPLAR AND WILLOW BORER (CRYPTORHYNCHUS LAPATHI L.)

By Paul Boisvert, School of Forestry, Laval University, Quebec.

During the past fifty years the study of insects injurious to trees has made considerable progress through the numerous investigations of entomologists in the various richly forested countries.

The poplar and willow are here considered as shade or ornamental trees, which because of their quick growth and hardiness are much in demand for road planting or for the embellishing of gardens and parks. Because of their comparatively small numbers and of their proximity to dwellings such trees can be easily cared for and protected from their enemies.

The increasing demand particularly for poplar, has given rise to a quite considerable trade in Quebec and Ontario. Several consignments of Carolina poplar reached their destination infested with a borer which Professor Georges Maheux, Provincial Entomologist determined as *Cryptorhynchus lapathi* L.— It seemed to us that a study of this insect would be of interest.

This species belongs to the family Curculionidæ which forms part of the Suborder Rhyncophora of the order Coleoptera.

Historical.

Linnaeus first described this insect in his "Systema naturæ". A century later it caused considerable loss in Germany and since 1880 many observations on its habits have been made in that country.

Several entomologists such as Fortsmeister, Ratzburg, Kamptz, Tachenberg, Altam and Fressler in Germany have contributed to our knowledge of this pest.

In England, Westwood first reported in 1863 an infestation in the willows in Essex.

In Denmark, Boas in an article on the coleoptera, described its habits and life cycle and reported the destruction of a plantation of young willows by this insect.

In 1882 the insect was observed in North America in the neighborhood of New York, in 1901 it was discovered in the central and northern portions of the United States. Fernald, Smith, Reinecke and Burgess, later Matheson (1905) and Schoene (1907) made studies on this pest. Burgess' studies included all phases of its development.

In Canada its appearance coincided with its discovery in the United States. It is found today to some extent throughout the Province of Quebec, but is seldom epidemic.

It constitutes, however, a danger to our ornamental trees, which cannot be ignored.

Entomologists claim that the borer is South American in origin, on that continent there are sixteen species, while in Europe and North America only the single species *C. lapathi* is found.

Description.

The full growth insect has a curious appearance because of the long legs—blackish like the rest of the body—which seem disproportionate in comparison with the size of the insect which they support. The beak is about the length of the body and when the insect is resting is carried in a groove in the stennum and projects between the coxal cavities. The chitinous thorax is rugose, decidedly punctate and coloured black as is the remainder of the insect except the tips of the elytra and the femora which are creamy white or grey. The two sexes are almost identical in appearance, but the male may be distinguished by its additional ventral segment. The body is thickset, almost cylindrical varying in length from 1-3 to 1-3 of an inch.

The full grown larva is about half an inch long. Its white, flehsy body is devoid of legs.

Habits.

The insect requires two seasons to complete its life cycle. The larva passes the winter in the galleries which it has eaten out during late summer and autumn.

Mating takes place towards the end of August and continues for a fortnight or more, and two weeks later the female lays from five to thirty eggs. The eggs, which hatch in 18 or 20 days are creamy white and about 1 mm. long. They are fragile and soft so that while normally oval in shape, they often assume the shape of the crack in which they are laid.

The freshly-hatched larva is a white, legless, plump grub a little over a millimeter in length. The head is touched with black in the region of the mouthparts. The body is sparsely covered with fine hairs.

The larva begins its work of destruction immediately, boring inwards from the cavity of the bark in which the egg was placed. Having reached the wood it changes the *direction* of its tunnel following the circumference of the trunk or branch.

The larvæ begin to hivernate in October, so that they have had little time in which to grow or to do much injury; but they resume their work towards the end of April or the beginning or May in our climate. The galleries are sinuous, irregular, the diameter enlarging as the borer increases in size. By the end of June the larvæ are ten or twelve times their initial size.

Up to July the galleries have been confined to the cambium, but as the time for pupation approaches the larvæ bore towards the pith where the last transformation will take place.

The approach of pupation may be recognized by the colour of the fras. This is dark while the borer is in the cambium or bark, but becomes whitish when it enters the wood.

When it enters the old wood the larva enlarges its gallery to form a chamber within which it passes the 12 to 15 days, while it undergoes its final transformation.

The pupa is immobile and about the same size as the adult. The body is yellow, the head and beak are furnished with small appendages and brown recurved hairs. The abdomen bears at its extremityt wo short, solid, recurved crochets.

The adults emerge usually about the end of July.

The adult although provided with well-developed wings seldom flies. Its habit of feigning death and falling to the ground makes it difficult to capture. It is never gregarious, seldom do we find two couples on the same branch.

Injury.

As previously mentioned the insect attacks chiefly the bark and cambium. The damage is due to the fact that the entire trunk may be covered with galleries, thus cutting off the food supply and weakening or even killing the host.

The bark situated above the galleries may die and fall off exposing the wood to the attack of fungi and bacteria. Indeed this is one of the principal contributing causes to the black rot so common among poplars. When the attack is confined to the branches the damage is often more considerable because a branch of small diameter can easily be encircled and killed.

The scars resulting from the attacks of the borer are rather unsightly and detract from the beauty of the trees. The bark loses its uniformity of colour and is touched here and there with black discolorations.

Trees from 2 to 12 years old are more liable to attack and therefore in

greater need of protection. One should make sure before planting that the trees are healthy.

Host plants.

C. lapathi feeds on all the species of willows, poplars and alders to Canada and the United States. Occasionnally young birch trees are also attacked.

Methods of control.

The affected trees or branches should be cut out and burnt before the end of June.

When the trunk of a young tree is infected it is sometimes practicable to cut open the galleries, kill the borer then clean and disinfect the wound and cover it over with some impermeable substance. The trees do not suffer appreciably from this treatment. The wound heals quickly and the danger of rot is averted.

The trees should be examined every spring in order that control measures may be resorted to before the injury becomes too great.

Matheson advises painting the bark with an emulsion of carbolineum in order to destroy the hibernating larvæ. This should be done in April preferably. The emulsion probably acts also as a repellant to the females, preventing them from laying on the treated trees.

An application of an arsenical spray towards the end of July may result in the poisoning of the adults.

It is important to know that the insect seldom migrates. Having become established in one tree the insect continues breeding here generation after generation.

There is little danger of an epidemic except in the case of young plantations from an infested nursery. This explains the large number of tunnels which may be found in a single poplar or willow. They represent the work of several generations.

It is important then to prevent the establishment of the pest in a plantation by careful examination of the trees each year to make sure of its absence.

Bibliography

1905—Felt, E. P. Mem. N. Y. State Museum Vol. I, pp. 100-103.
1907—Schoene, W. J., Bull. 286, N. Y. Agr. Exp. Sta.
1915—Matheson, R. Jour. Econ. Ent. I, 522-525.
1915—Blackman, M. W. & Ellis, W. O. Bull. 26, N. Y. State College of Forestry, pp. 67-71.
1918—Houser, J. S. Bull. 332, Ohio Agr. Exp. Sta. 319-320.
1924—Felt, E. P. Manual of Tree and Shrub Insects, pp. 57-58.
1925—Maheux, G. Cours d'Entomologie Forestière, Université Laval, Quebec.

THE CABBAGE WHITE IN QUEBEC

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Among the numerous enemies of the cabbage the white butterfly (*Pieris rapea*) is one of the most worthy of our attention because of the amount of injury it causes. We are so accustomed to the work of this insect that we usually pay little attention to it, yet as the figures given below will show, it is an insect of considerable economic importance in the Province of Quebec.

The insect was introduced into Canada in the neighbourhood of Quebec about 1860 and spread rapidly to all parts of the country. In 1863 they could be counted by the thousands in Quebec City and in 1865 were found at Murray Bay 90 miles north east of this City.

The cabbage is an important crop in Quebec. Each year there is sown about 350 lbs. of seed of winter-cabbage and about 150 lbs. of summer and fall cabbage. The crop is distributed as follows: Montreal Island 75% Quebec and eastward 10%, Sherbrooke & Ste. Hyacinthe 5%, Three Rivers, Shawinigan and Grand'mere 5%, Lake St. John 2⅛ %, Hull and vicinity 2⅓%. Counting only 40,000 plants per lb. of seed, the crop amounts to about 20,000 tons of winter cabbage and 9000 tons of summer and fall cabbage having a value of nearly $1,000,000.

A survey taken among several of the growers in the vicinity of Montreal showed a loss of 6% to 8% in winter cabbage. This insect then causes an annual loss of 1,400 tons of winter cabbage valued at $42,000. Our estimate is not exaggerated because Chittenden states that in the United States the annual loss exceeds $1,300,000, one tenth of the value of the crop.

The insect does not limit its attacks to the cabbage. It feeds readily on other crucifers and the cauliflower is attacked as readily as the cabbage. The radish is rarely attacked. In the spring I have seen it feeding on the wild mustard (*Brassica arvensis* L.) and on the shepherd's purse (*Capsella bursa-pastoris*).

Most of the injury is done to the winter cabbage, the early cabbage and cauliflower are marketed before the insect becomes very numerous. The appearance of the infested plant varies according to the severity of the attack. Sometimes only the outer leaves are attacked. In severe cases all the parenchyma may be eaten so that after a while only the stalks and larger leaf-veins remain on the plant. The young leaves are destroyed as they appear, no head is formed and the plant has no commercial value.

Life history and description.

The insect hibernates as a pupa in sheltered places such as cracks or crevices in walls, fences and trees. The pupae observed this winter did not have the characteristic pale green colour of the summer pupae, but were rather of an ashgray shade.

By the first fine days of spring, that is, towards the end of May in the district of Montreal (28th May, in 1925) the butterflies emerge and begin to fly about the fields. Several days later the females begin to lay, giving rise to the first generation.

On the 3rd of June I captured several females to breed in cages. These laid an average of 201 eggs each;37 on the first day, 65 on the second, 63 the third, 24 the fourth, and 12 the fifth.

It is interesting to observe the female about to lay. She rests on the leaf, recurves her abdomen pressing the ovipositor firmly against the epidermis. She remains in this position for some time then straightens the abdomen and deposits an egg. Unlike other Pierids the cabbage white does not lay its eggs in masses. The eggs are oval and lemon yellow in colour. With a magnifying glass 10 or 11 longitudinal striations may be observed on the surface.

The incubation period varies, usually 5 or 6 days according to the time of year. The colour changes as development proceeds. At the time of hatching a longitudinal split appears in the egg. This opening is enlarged by the larva which eats its envelope as it pushes its head out of the egg. The rest of the body follows quickly since the head is disproportionately large, The freshly emerged caterpillar measures 1.5 mm. and is pale green in colour.

At the first moult the insect have not migrated from the place of hatching. After the third they migrate to all parts of the plant. They feed night and day and are found oftener on the lower than on the upper face of the leaf. Often the young larva works towards the head of the cabbage, burrows into it and appears on the surface again when ready to pupate. The larva is then about 1½ inch and deep green in colour. It seeks out a suitable place and changes into the chrysalis. The larval stage lasts for 18 to 28 days. The chrysalis is pale green in colour. It changes into the adult butterfly in 9 to 11 days.

The cabbage white in 1925.

The first butterflies appeared in small numbers on May 28th; by June 3rd they had become quite numerous. The generation lasted until the beginning of July. By the 3rd or 4th of July the adults of the second generation were abundant. These gave rise to a third generation about August 2nd to 6th. Many of the larvae of this third generation were killed by the frost; others gave rise to pupae which hibernated. There are thus three distinct generations in Quebec.

Natural enemies.

Several hymenopterous insects prey on the cabbage worm. The two most important are *Apanteles glomeratus* Linn. and *Pteromalus puparum* Linn. These two parasites were imported from Europe in 1870-1 and 1880 respectively. Both of these insects lay large numbers of eggs within the caterpillar. The *Apanteles* larvae leave the caterpillar and spin their cocoons on and around its dead body.

Pt. puparium passes its entire life cycle within the insect.

From one of our breeding experiments, we obtained an unidentified tachinid fly.

Every year large numbers of caterpillars are destroyed by a widespread disease known as flacherie. The caterpillars in the initial stages of the disease show little change in the external appearance but they stop feeding and become flaccid. Death often results at this stage. Later the colour may change through brown to black, and the body become shrivelled.

Control.

On account of the serious ravages of this insect, its control is of prime importance to the gardener.

Last summer we carried out experiments at Ste. Dorothee and St. Michel on various forms of arsenicals. As far as possible the fields chosen were of the same size and of a similar degree of infection.

Following is a summary of our results:—

Material	Results
Calcium Arsenate dust 1 in 10.	Cabbages developed well but outer leaves freely eaten and killed.
Calcium Arsenate dust 1 in 15.	As above.
Lead Arsenate dust 1 in 15.	Excellent control. All caterpillars dead on second day.
Calcium Arsenate 2 lbs. Water 50 gal. Lime 10 lbs. Sticker ½ lb.	Fairly good results. Some burning. Good adherence.
Calcium arsenate 3 lbs. other gredients as above.	Nearly all caterpillars killed. Some burning.

The results showed the superiority of dusting over spraying. This is due to the difficulty of getting the spray to adhere to the leaves owing to the coating of wax on the surface of the latter. To overcome this difficulty it is necessary to use soap or a commercial sticker. Besides it is more difficult to make a good spray than a good dust, and takes more time.

Lead arsenate seems to be somewhat superior to calcium arsenate and did not burn the foliage in our experiments.

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